UTHealth® Houston

Environmental
Health and Safety

The University of Texas Health Science Center at Houston

Radiation Safety Manual

Safety, Health, Environment & Risk Management
Environmental Health & Safety
Radiation Safety Program

February 2023

PREFACE

The objective of The University of Texas Health Science Center at Houston (UTHealth Houston) Radiation Safety program is to assist all levels of management in fulfilling the UTHealth Houston commitment to furnish a place of employment and learning that is as free as possible from recognized radiation hazards that cause or are likely to cause harm to UTHealth Houston personnel or the surrounding community. It is vital that faculty, staff and students have enough information available to aid them in the safe conduct of their daily work activities relating to radioactive materials and devices.

To that end, the Texas Department of State Health Services, Radiation Control Program issues a broad license to the UTHealth Houston authorizing the use of radionuclides and a registration authorizing radiation-producing devices. An essential component of that license is this Radiation Safety Manual. A significant factor in being allowed the flexibility of a broad license by the Texas Department of State Health Services is that UTHealth Houston implicitly accepts the responsibility to regulate and control the broad use of radioactive materials and radiation-producing machines within its jurisdiction. This responsibility is not to be taken lightly.

The purpose of the UTHealth Houston Radiation Safety Manual is to assist both personnel and management in complying with the objectives of the Texas Department of State Health Services, Radiation Control Program regulations and the UTHealth Houston and Safety Policies. Many of the items in this manual are addressed in the periodic Radiation Safety training sessions provided by the Radiation Safety Program.

This manual is not intended to be an exhaustive or fully comprehensive reference, rather a guide for authorized users and other technically qualified individuals. Further advice concerning hazards associated with specific radioactive substances, devices and the development of new or unfamiliar activities should be obtained through consultation with the Radiation Safety Committee, the Radiation Safety Officer or the Radiation Safety Program.

All users of radioactive material and radiation producing devices must be familiar with the requirements set forth in this manual and applicable regulations of the Texas Department of State Health Services, and must conduct their operations in accordance with them.

Ambro van Hoof, Ph.D.
Chair, Radiation Safety Committee
The University of Texas
Health Science Center at Houston

Giuseppe N. Colasurdo, M.D.
President, The University of Texas
Health Science Center at Houston

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1. Purpose and Scope

This manual is designed to support the safe and effective use of radioactive materials and radiation-producing machines in research, education, and medical science. This manual addresses specific actions and procedures required of its users as they function within the administrative, technical, and physical environments encountered at UTHealth Houston.

This manual is *not* intended to replace the official regulations as enforced by the Texas Department of State Health Services, Radiation Control Program in the form of the 25 *Texas Administrative Code* (*TAC*). It will, however, provide valuable guidance and information related to UTHealth practices, policies and procedures for Authorized Users. All Authorized Users and their staff should become familiar with the *TAC* sections that may apply to their particular applications. As a State of Texas Licensee, UTHealth shall comply with all applicable provisions of Parts §289.201-289.260 of the 25 *Texas Administrative Code (TAC).*

The current copy of the *25 TAC §289* can be found online at http://www.dshs.texas.gov/radiation/laws-rules.aspx. For radiation use where a computer with internet access is not available nearby, the applicable rules can be printed.

An effort has been made in developing this edition of the manual to group all standard charts and forms in the Appendices. Although the bulk of this document shall be considered literal commitments for policy and procedure to DSHS-RCP, the formats and administrative content of the forms as collectively grouped in Part 2 shall be revised pending the approval of both the Radiation Safety Officer and the Radiation Safety Committee. New forms can also be added. No changes shall be approved that would result in any condition of noncompliance with applicable regulations or license conditions. The Radiation Safety Program will submit to the DSHS RCP within 30 days of final approval, copies of revised forms that have changed substantially.

In keeping with the definition used by the National Council on Radiation Protection and Measurements, the verb "shall" denotes that the ensuing recommendation is necessary or essential to meet the currently accepted standards-of-protection. The verb "should" indicates advisory recommendations that are to be applied when feasible.

2. Organization and Responsibilities

2.1 The University of Texas Health Science Center at Houston

The University of Texas Health Science Center at Houston (UTHealth Houston) is a dynamic institution of higher learning located in the world's largest medical center. Radiation sources employed at the institution predominantly as tools for research, with onsite activities facilitated by the issuance of a broad radioactive materials license by the Texas Department of State Health Services, Radiation Control Program. Radiation is also used for diagnostic purposes in several locations throughout the campus in the form of registered x-ray machines. The UTHealth Houston registration also includes the UT School of Public Health Satellite Brownsville campus.

2.2 Radiation Safety Organization and Policy

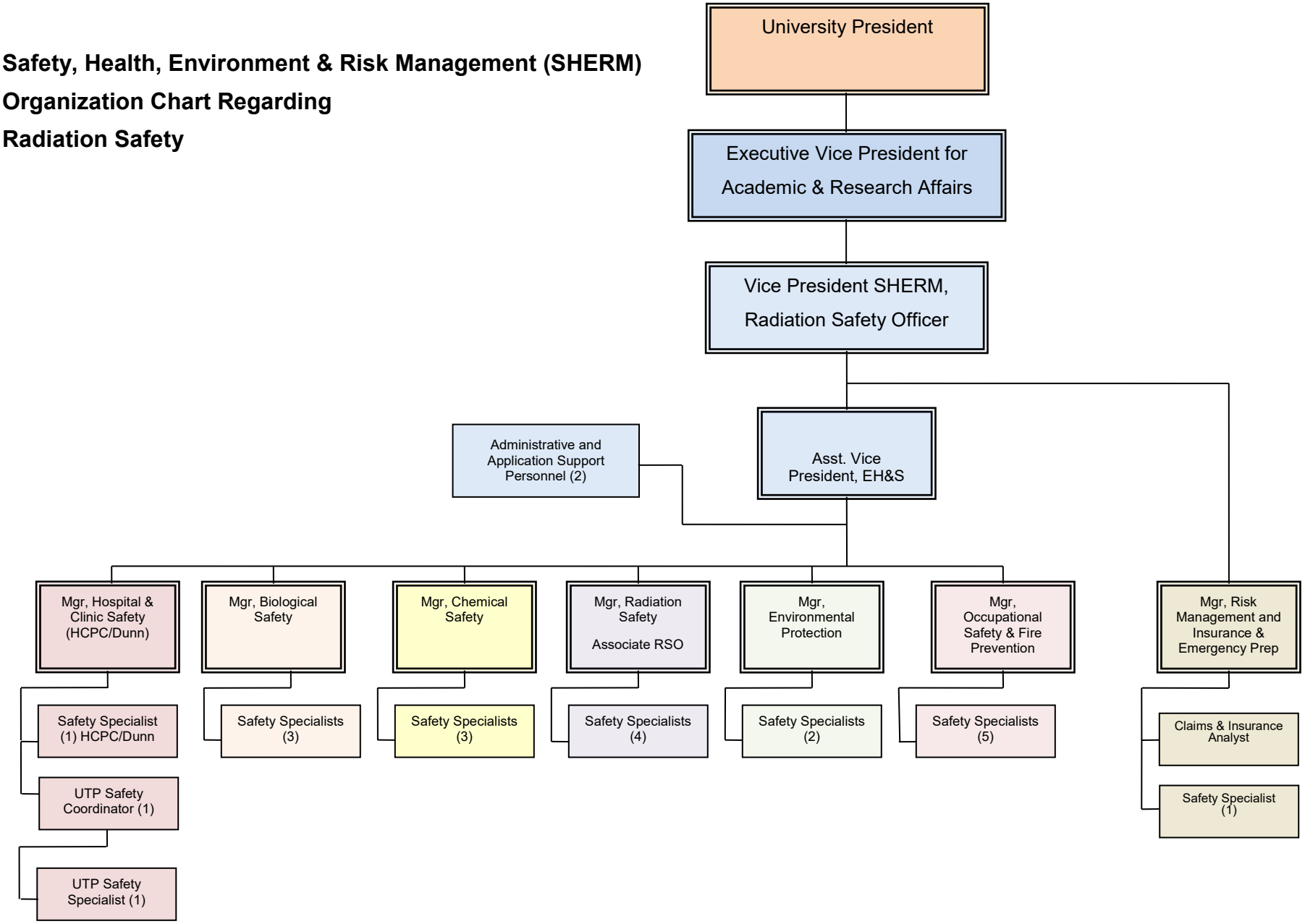
The fundamental objective of a radiation safety program is to ensure the safety of UTHealth Houston faculty, staff, and other employees while enjoying the scientific benefits available through the use of radioactive materials and radiation-producing machines. No less imperative is the need for protecting the general public and the environment from avoidable additional radiation exposure and contamination as the result of licensed activities at UTHealth

Houston.

In matters related to radiation protection of UTHealth Houston workers and the general public, the principle of As Low As Reasonably Achievable (ALARA) shall be exercised. In this way, unnecessary radiation dose (and resulting additional health risks) can be avoided. Following the ALARA principle means making efforts to maintain exposures to radiation at a minimum, taking into consideration the state of technology, economic factors, benefits to the public and other societal and socioeconomic considerations.

An effective broad-license radiation safety program is governed using a two-tier approach. The Radiation Safety Committee directs policy relying on the diverse expertise of UTHealth Houston resources. Additionally, the Radiation Safety Officer guides administrative support necessary to maintain compliance. The included organization charts detail the participating structure and responsibilities composing the UTHealth Houston radiation safety hierarchy. An integral component of the "administrative chain" for a radiation safety program is the ability to enforce safe practices and regulatory compliance should sensitivity to these issues be lacking in individual situations.

Safety, Health, Environment & Risk Management (SHERM)
Organization Chart Regarding
Radiation Safety



The following section of this manual documents the specific responsibilities of the individual organizations, administrators and individuals at UTHealth Houston that bear portions of the institutional radiation safety responsibilities.

2.3 Radiation Safety Committee

2.3.1 Committee Function

The Radiation Safety Committee (RSC) is responsible for formulating policy about the use of radiation sources and for regulating their use in compliance with Texas Department of State Health Services regulations and UTHealth Houston policy. The RSC reports to the President. In this regard, the committee serves as the primary regulatory body for the institution in all matters related to the use of radioactive material and radiation-producing devices in health-related investigative research. Changes in 2013 to the Texas Regulations for the use of x-ray machines in the healing arts required the formation of a Radiation Protocol Committee for CT Systems and FGI Procedures. On March 20, 2013, the RSC decided to appoint a sub-committee for the Radiation Protocol Committee for CT Systems and FGI Procedures. This scope of this sub-committee is to review UTHealth Houston's CT and fluoroscopy machines using FGI procedures with regard to the protocols, action thresholds and patient dose estimates. This sub-committee may also be joined with other institutions.

2.3.2 Committee Appointments

Members are appointed by the president. In general, committee appointments are for a three-year term. Members of the Committee include:

- One faculty representative from the School of Dentistry
- One faculty representative from the Graduate School of Biomedical Sciences
- One faculty representative from the School of Public Health
- One faculty representative from the Cizik School of Nursing
- Three faculty representatives from the McGovern Medical School, representing the three main disciplines: education, research and clinical/patient care.
- Two representatives of the administration (*ex officio*)
- The Radiation Safety Officer (*ex officio*)
- The Associate Radiation Safety Officer if designated *(ex officio)*
- The Radiation Safety Officer for radioactive material, Memorial Hermann Hospital Texas Medical Center (*ex officio*)
- Optional student member(s) from any of the UTHealth schools
    - Student member(s) are nominated by the Office of the President. If there is more than one student serving the students will be represented only by a single vote.
- Optional community member without vote nominated by the Office of the President.

Other members may be appointed at the discretion of the President.

2.3.3 Committee Meetings

The committee shall meet at least six times per year, upon due notice by the chair, who shall advise committee members of the time and place of the meetings. A Radiation Safety Committee quorum shall exist when at least fifty percent of the membership is present. Included in the quorum shall be the Radiation Safety Committee Chair, or designee, and the Radiation Safety Officer, Associate Radiation Safety Officer or designee. The RSO designee may be the EH&S director, the Radiation Safety Program Manager (Associate Radiation Safety Officer), the Environmental Protection Program Manager or another designee that represents management. In

the absence of a meeting call from the chair, and if pending business before the committee requires timely resolution, a meeting may be called by the Radiation Safety Officer, Associate Radiation Safety Officer, or by any three regularly appointed members of the committee. The proceedings of each meeting shall be transcribed, published and circulated to committee members, and may be made available to interested persons upon request with security sensitive information excluded.

2.3.4 Committee Functions and Responsibility

The Radiation Safety Committee is responsible for the following:

A. Review and approval of policies and procedures governing the use of radioactive materials and radiation-producing equipment.
B. Review and approval of applications for possession and use of radioactive materials within the UTHealth Houston. Review and approval of research procedures with radiation producing devices.
C. Review and approval of policies and procedures regarding the disposal and release of radioactive effluents from UTHealth Houston.
D. Review and approval of amendments to the radioactive materials broad license, to be submitted to the Texas Radiation Control Program.
E. Provision of professional advice to the president or his designee regarding the Radiation Safety Officer's qualification and performance.
F. Provision of professional advice to the Radiation Safety Officer and/or the Associate Radiation Safety Officer on matters regarding radiation safety.
G. Review and action regarding requests for installation, removal, change of location, structural and shielding changes, and operational changes of radiation-producing machines.

2.3.5 Sub-Committee - Radiation Protocol Committee for CT Systems & FGI Procedures

Members of the Sub-Committee include representation of at least the following representation of disciplines from within the RSC. Additional members may serve as needed. When the Sub-Committee reviews other institutions as well, at least one member should represent the other institution.

- Radiologist (A physician with a specialty in using ionizing and non-ionizing radiation for medical imaging and interpretation)
- Radiation Safety Officer for the radiation producing devices permit(s)
- Licensed Medical Physicist

A. The Sub-Committee will meet no less than once every 14 months. Minutes of these Sub-Committee meetings may be summarized and should be presented to the RSC.
B. The Sub-Committee is tasked with reviewing the protocols for CT systems and FGI procedures under their oversight sight, maintaining action thresholds, ensuring patient estimated doses are monitored (maximum $CTDI_{vol}$ preferred), and investigating and acting for any cases above the action thresholds.

2.3.6 Committee Disciplinary Mechanisms

Investigation of safety violations may be initiated by the Committee or the Radiation Safety Officer of any facilities where radiation sources are used. Promptly, upon completion, a report of the investigation shall be submitted to the committee for review and appropriate action.

After consideration of the violation report, the committee may:

A. Make a recommendation for mandatory remedial action. Failure to comply with

committee remedial action may result in withdrawal of the Committee's approval of the investigator's radioactive material use authorization, or

B. Revoke the authorization forthwith, if the violation significantly endangers the health or safety of persons or property. In the event the committee withdraws its approval, the activity shall no longer be carried out within UTHealth Houston until a new authorization application has been submitted, reviewed and approved.

The investigator involved has the right to be present at the committee hearing and to present his or her position.

2.4 Radiation Safety Officer

2.4.1 Role of the Radiation Safety Officer

The Radiation Safety Officer (RSO) is responsible for investigating incidents, monitoring and implementing established policies on matters relating to radiation safety and is the Radiation Safety Committee's authorized representative regarding radiation protection within UTHealth Houston. The Radiation Safety Officer may delegate responsibilities to the Radiation Safety Program Manager or other individuals pending appropriate qualifications pertaining to these assigned duties.

2.4.2 Emergency Authority

The Radiation Safety Officer shall have the responsibility and authority during a suspected or confirmed emergency to take prompt remedial action without prior approval of the Radiation Safety Committee or the president of UTHealth Houston. Should such independent action be required, the Radiation Safety Officer shall promptly report details of the situation to both the president of UTHealth Houston and to the Radiation Safety Committee.

2.4.3 Radiation Safety Officer Function and Responsibility

The responsibilities of the Radiation Safety Officer are as follows:

A. to establish and oversee operating safety, emergency, and ALARA procedures, and to review them at least annually to ensure that the procedures are current and conform with 25 *TAC* rules available at: http://www.dshs.texas.gov/radiation/laws-rules.aspx;

B. to oversee and approve all phases of the training program for operations and/or personnel so that appropriate and effective radiation protection practices are taught;

C. to ensure that required radiation surveys and leak tests are performed and documented in accordance with these rules, including corrective measures when levels of radiation exceed established limits;

D. to ensure that personnel monitoring is used properly by occupationally-exposed personnel, that records are kept of the monitoring results, and that timely notifications are made as required by 25 *TAC* § 289.202 available at: http://www.dshs.texas.gov/radiation/laws-rules.aspx;

E. to investigate and cause a report to be submitted to the Agency for each known or suspected case of radiation exposure to an individual or radiation level detected in excess of limits established by these rules and each theft or loss of source(s) of radiation, to determine the cause(s), and to take steps to minimize a recurrence;

F. to investigate and cause a report to be submitted to the Agency for each known or suspected case of release of radioactive material(s) to the environment in excess of limits established by these rules;

G. to have a knowledge of management policies and administrative procedures of the license;

H. to assume control and have the authority to institute corrective actions, including

shutdown of operations when necessary in emergency situations or unsafe conditions;

I. to ensure that records are maintained as required by 25 *TAC* regulations;
J. to ensure the proper storing, labeling, transport, and use of sources of radiation, storage, and/or transport containers;
K. to ensure that inventories are performed in accordance with the activities for which the license application is submitted;
L. to ensure that personnel are complying with these rules, the conditions of the license, and the operating, safety, and emergency procedures of the license;
M. to supervise the radioactive waste disposal program through the Environmental Protection Program;
N. prepare reports on the function of the RSP for presentation to the RSC at their regular meetings. The RSO will document and present an annual audit of RSP activities to the RSC. Copies or summaries of this audit will also be forwarded for senior management review and maintained for inspection.

2.5 Associate Radiation Safety Officer (ARSO)

An Associate Radiation Safety Officer (ARSO) may be designated only on the radioactive material license who meets the regulatory requirements and has been assigned radiation safety duties and tasks by the radiation safety officer (RSO). Records of the ARSO appointment must include the signature of the RSO and licensee management. The radiation producing devices' permit requires only a single RSO point of contact.

2.6 Radiation Safety Program

The Radiation Safety Program (RSP) within Environmental Health & Safety (EH&S) is responsible for all aspects of the operational radiation safety program at UTHealth Houston. The Radiation Safety Officer provides direction to the Radiation Safety Program Manager and the Radiation Safety Program. The operational radiation safety program stewards the implementation of the policies and procedures as prescribed by the Radiation Safety Committee and promulgated in applicable state and federal regulations and relevant UTHealth procedures.

2.6.1 Radiation Safety Program Function and Responsibility

The responsibilities of the Radiation Safety Program include:

A. maintain timely radiation and contamination surveys for control of worker and student radiation exposure and protection against unnecessary exposure to the public;
B. recommend, provide, and manage personnel radiation dosimetry;
C. ensure that Authorized Users operate in compliance with applicable regulations and within the scope approved by the RSC;
D. perform investigations of abnormal events, *e.g.*, spills, suspected radiation overexposure situations, and lost or stolen radioactive materials;
E. formulate, maintain, and conduct radiation safety training for new faculty, staff and student employees at UTHealth Houston;
F. establish and maintain programs for the authorization of procurement, use, and disposal of radioactive material at UTHealth Houston. This program will control inventory and shipping of all radioactive material and radiation producing machines. As a parallel procedure, the RSP shall maintain an inventory of all licensed radioactive materials and registered radiation-producing machines at UTHealth Houston;
G. perform and document regular radiation safety inspections of laboratories and other areas in which radioactive materials and radiation-producing machines are used.

Determine compliance with state and federal regulations and additional constraints imposed by the RSC;

H. provide management oversight of the radioactive waste disposal program for materials generated by UTHealth Houston licensed activities. These activities are performed in conjunction with the Environmental Protection Program, and includes the handling of surplus radioactive materials and sources;
I. serve as advisor and source of unbiased information for UTHealth Houston radiation workers concerned about effects of radiation on their health and safety;
J. perform and document regular leak tests for sealed radioactive sources;
K. oversee the posting and maintenance of signs, notices, emergency response contacts and other information as required by 25 *TAC*;
L. make available to UTHealth Houston radiation workers the online link of all applicable state and federal regulations pertaining to safe use of licensed materials and registered equipment;

2.7 Department Chairs and Administrators

Department chairs and technical program administrators shall maintain current knowledge of radioactive material and radiation-producing machine use within the scope of their responsibilities.

They should be aware of the need for approvals from the RSC before initiation of research and other projects involving radioactive materials or radiation-producing machines within their area of responsibility. Information on new users or termination of Authorized Users or extended absence from UTHealth Houston shall be reported promptly to the RSO.

The individuals should be aware of the need for radiation safety considerations in the design and construction of new facilities and buildings in which the use of radioactive materials or radiation-producing machines are planned. Also, plans for disposal or designation as surplus for radiation-producing machines or equipment in which radioactive sources are or may be installed shall be reported to the RSO before transfer or disposal.

2.8 Authorized User

An authorized user is an individual who by virtue of position, training and experience is designated by the RSC as a user of radioactive material under the UTHealth Houston broad radioactive material license. This authorization permits the procurement and use of radioactive material within a defined protocol or work activity under the supervision of the authorized user provided that the materials are used within the guidelines of safe practice, and within the rules, regulations and recommendations of the RSC and UTHealth Houston policy.

2.8.1 Authorized User Function and Responsibility

All Authorized Users of radioactive materials must comply with the conditions of their authorization and of the radioactive material licenses of the UTHealth Houston. A partial list of specific responsibilities of the Authorized User is provided below to assist the user in maintaining good safety practice. (Additional information is included throughout this manual.)

The Authorized User shall:

A. Establish and maintain an awareness of the need for radiation safety in the workplace. This shall include control of radiation exposure to the lowest reasonable level (ALARA).
B. Ensure the following services for laboratory areas and radiation workers under their supervision are provided:
    1. appropriate personnel dosimetry if likely to exceed 10% of dose limits;

2. bioassay services if applicable;
3. personal protective equipment;
4. availability of appropriate and calibrated survey instrumentation;
5. availability of appropriate radiation detector for wipe tests; and
6. facility maintenance.

C. Follow procedures for procurement of radioactive materials and radiation-producing devices.
D. Provide correct and current posting of laboratory areas, radioactive material containers and radiation-producing equipment.
E. Ensure maintenance of accurate and current inventory records for all radioactive materials under his or her responsibility.
F. Follow established procedures for packaging, inventory listing, disposal and notification of the Environmental Protection Program for collection of radioactive wastes.
G. Report immediately to the RSP any potentially hazardous spills, suspected radiation overexposures, loss or theft of radioactive materials, or other incidents having possible radiation safety implications.
H. Perform radiation and contamination monitoring as required by applicable regulations, procedures in this manual, and commitments to the RSC. Maintain accurate records of such monitoring results.
I. Provide adequate use-specific safety training for all radiation workers under their supervision. This supplements the general employee radiation safety training provided by the RSP.
J. Notify the RSP of any need for changes in the authorized use of licensed materials or registered equipment. This includes changes in use as well as for a need for larger quantities. As determined by the RSO, such changes may require the review and approval of the full RSC.
K. Obtain the prior approval of the RSP during procurement of radioactive materials.
L. Follow established procedure for transfer of licensed radioactive materials to other authorized UTHealth Houston users.
M. Arrange with the RSP for appropriate actions in the event of anticipated extended absence from UTHealth Houston.
N. Arrange for disposal or transfer of all radioactive materials promptly upon termination of the authorized use or application.

2.9 Individual

One of the basic tenets of safety programs is that individuals must take responsibility for their own safety in daily activities, and must ensure that any personal actions do not contribute to increased hazard to coworkers or to the environment.

2.9.1 Individual Function and Responsibility

The responsibilities of the individual include:

A. Maintain awareness of and compliance with applicable regulations, license commitments, RSC restrictions, and standards of good safety practice (such as those presented in this manual or other UTHealth Houston safety manuals).
B. Maintain required records, *e.g.*, laboratory contamination surveys, radioactive material inventory, waste disposal records, *etc.*, in collaboration with the Authorized User.

C. Notify the Authorized User or the Radiation Safety Program promptly of incidents, spills, personnel contamination, or significant contamination of UTHealth Houston facilities.
D. Maintain awareness of need to minimize personal radiation dose in accord with the principles of As Low As Reasonably Achievable (ALARA).
E. Ensure proper use of personnel dosimetry if issued. This includes proper wear location (at the belt, on the collar, etc.), timely exchange for new dosimeter and storage in proper location when not in use to guard against deceptive exposure of the dosimeter.
F. Assist the Authorized User in maintaining proper posting of work areas and labeling of radioactive material containers.
G. Be familiar with the radiation safety precautions in their specific work areas. This should include procedures for safe use of radioactive materials and correct operating procedures for radiation-producing equipment.

2.10 Rights of the Radiation Worker

As required by the *Chapter 25 Texas Administrative Code (TAC)*, copies of the current RC Form 203-1 "Notice to Employees" (available on RC's website (http://www.dshs.texas.gov/radiation/laws-rules.aspx) under §289.203 (Notice to Employees by Itself)) shall appear in a sufficient number of places to permit individuals engaged in activities under the license or registration to observe them in a work locale. This document lists the rights of radiation workers and the address of the Texas Department of State Health Services Radiation Control Program to which the worker has access.

Some specific rights are:

A. Access to the current 25 TAC which is available online at http://www.dshs.texas.gov/radiation/ram/laws-rules.aspx. For assistance in accessing the rules, contact the Radiation Safety Program at 713-500-8100.
B. Access to licenses, certificates of registration, notices of violation and operating procedures that applies to work in which the worker is engaged.
C. Explanation of relevant regulations, licenses, certificates of registration, notices of violations and operating procedures as given above.
D. Instruction in basic principles of radiation safety.
E. A written report of a radiation exposure in excess of any applicable limit as set forth in the regulations or in the license.
F. Upon the worker's written request to the RSP, an annual report of exposure to radiation.
G. If you work where individual monitoring devices are provided in accordance with 25 TAC §289.202 or §289.231, an annual written report of your occupational exposure to radiation will be provided to you if your annual occupational dose exceeds 100 mrem (1 mSv) total effective dose equivalent or 100 mrem (1 mSv) to any individual organ or tissue.
H. Upon termination of employment at the UTHealth Houston, and upon the worker's written request to the Radiation Safety Program, a report of radiation exposure regardless of the amount of exposure.
I. The right to request an inspection by the Texas Department of State Health Services, Radiation Control Program (RCP). The UTHealth Houston may not terminate employment or discriminate against the employee because of such action.

3. Licensing Requirements and Conditions

3.1 General Requirements

The UTHealth Houston operates under a broad license for the use of radioactive materials in research and development as issued by the Texas Department of State Health Services, Radiation Control Program (RCP). Under the conditions of the broad license, the Radiation Safety Committee (RSC) may issue authorizations for specific radioactive material usage. The RSC also may withdraw authorizations. Although possession and use of radiation-producing machines is not covered under the RC broad license, but under separate registrations, the RSC possesses the authority and responsibility for control of such uses at UTHealth Houston. Therefore, before any investigator may acquire, possess, or use any quantity of radioactive material or any radiation-producing device, authorization by the RSC shall be obtained.

3.2 Application for Non-Human Use of Radioactive Material

In general, application for authorization to use radioactive materials (excluding human or animal use) requires the submission of four forms:

A. Form RS-01A - Application for Non-Human Use of Radioactive Material
B. Form RS-01B - Training, Experience, Laboratory Staff, and Equipment Addenda
C. Form RS-02* - Radiation Safety Training and Experience (optional form)
This form provides a record of the institution(s) and date(s) of the training and experience of radiation workers not provided in the RS-01A and RS-01B (e.g. authorization amendments).
D. Form RS-03 - Dosimetry Service Request and Exposure History Form
These forms are available from the Radiation Safety Program Website at https://www.uth.edu/safety/radiation-safety/. There are three RS-03 dosimetry forms based on the permits and locations of use.

Forms RS-02 and RS-03 may be required from technicians and other personnel who may potentially be exposed to radiation while working on a project. If occupational doses are not likely to exceed 10% of the occupational dose limit, then the RS-03 form is not required.

3.2.1 Filing the Application

After completing the applicable forms, the investigator should send them to the RSP or ARSO for review. If required, the investigator will be contacted to arrange an appointment to further discuss the application with the RSO, ARSO or their designee. The investigator is also asked to provide, if possible, any additional supportive documentation to demonstrate prior training and experience with sources of radiation. Such documentation might include a copy of a specific radioactive materials license that identifies the individual or, a letter from a previous RSO attesting to the formal training, experience and compliance history.

3.2.2 Processing the Application

In general, new applications for the acquisition and use of radioactive material may require the completion of Forms RS-01A, RS-01B, RS-02, and RS-03.
The application review procedure will generally include the following parameters:

A. Whether the procedure can be carried out safely, including:
- Need for appropriate personnel monitoring and/or bioassay
- Frequency for surface contamination surveys to be performed in lab
- Primary users' availability to perform adequate and frequent supervision

B. Whether the individual user and all others involved are qualified, including:
- Appropriate training and experience of users

- Identify users/staff and/or assistants to work under sublicense
- Enough in-service training for any handler of radioactive material

C. Whether the laboratory design and location are suitable including:

- Engineering controls,
- Hoods,
- Ventilation,
- Shielding,
- Sinks.

D. Whether adjacent low-level counting work will be affected.

The RSO or ARSO may also formally request from the investigator, documentation that confirms prior training and experience with radiation sources. Following this analysis, the application is referred to the RSC for consideration and approval.

3.2.3 Radiation Safety Committee (RSC) Review

The review of the request for authorization by the committee may have several scenarios. In the most obvious and frequent occurrence, the applicant exhibits sufficient training and experience (generally a minimum of 100 hours combined training and experience in the use of radioactive materials in the same or in a similar type of use as that contained in the application). In this case, the application normally is approved by the RSC.

In another situation that occasionally may occur, the applicant is knowledgeable in a variety of other procedures, but has no practical experience in the particular proposed use. This application may be assigned for some specified time period by the RSC to an existing authorized user with expertise in the area of use that the applicant is lacking. This authorized user shall be named as such and sign the application; must supervise a dry-run or pilot program, as well as the actual performance of the research; and become the responsible person who must ensure the safe use of the radioactive material within the laboratory. This responsibility will continue until the authorized user can report to the RSO that the applicant can proceed without further special surveillance. In such cases, the applicant is advised to make arrangements with an authorized user well in advance of submitting the proposal so that delays in the review are avoided.

NOTE

The applicant's signature on the application signifies a desire and intention to do the work, competency to perform it (if with assistance) and the willingness of all persons working on the project to comply with the terms of the Radiation Safety Manual and the UTHealth Houston radioactive material license.

In sponsoring another investigator, the authorized user accepts responsibility to serve in an advisory and consultative capacity, to supervise the procedure as specified, and to be responsible for overall radiation safety of the project.

Approval of an authorization for radioactive materials may be dependent upon the stipulation that certain equipment must be included as part of the project and/or that specific procedures must be followed.

3.2.4 Approval of Application

Approval by the RSC results in the granting of a sublicense to the Authorized User. This sublicense should be comprised in form of the approved RS-01A, RS-01B and a memo on behalf of the RSC. This memo will contain notification of the committee's decision, and any

stipulations, restrictions or special conditions placed upon the sublicense. Use of any of the privileges of the sublicense represents agreement in whole with the terms and conditions of the sublicense. The Authorized User may then acquire and use the radioactive material according to the specifics of the sublicense. In the event that the committee does not approve the application, it will be returned to the investigator with recommended corrective measures for deficient aspects. When the unsatisfactory conditions that led to deferral or disapproval have been remedied, the application may be resubmitted and will be reviewed in light of the new information. An authorization to possess and use radioactive material may be suspended or withdrawn by the RSC for failure to observe and comply with any condition of the UTHealth Houston broad license or of the Radiation Safety Manual, or as warranted by unsafe or improper conditions.

3.3 Amendment of the Authorization

An authorization is valid only for the protocols stated in the original application. Minor changes to the authorization may be warranted and made without affecting its validity by requesting in writing or electronic mail and specifically stating the changes desired. However, if in the judgment of the RSO, alterations in the conditions materially compromise radiation safety, the authorization may be withdrawn for further review by the RSC. Another application may then be submitted and will be reviewed on its own merit.

Addition of **new** radionuclides to the authorization **requires** only the submission of an additional Form RS-01A "Application for Non-Human Use of Radioactive Material" for that radionuclide.

The following items are frequently changed during the course of an investigation. It is important that the Radiation Safety Program be notified in writing or electronic mail of significant changes. Form RS-11, the "Radioactive Material Authorization Amendment Form" may be used to notify the Radiation Safety Program of changes in users or staff, changes in activities, addition or decommission of a laboratory.

3.3.1 Changes in Users and Staff

For changes in staff working under an Authorized User, Form RS-11 may be filed with the Radiation Safety Program. Added staff may either submit form RS-02 or convey these changes to the RSP. For employees added to the dosimetry program, submit the applicable RS-03 Form. Personnel dosimetry will be issued as required with the RS-03 Form.

3.3.2 Changes in Radionuclides or Quantities

For changes in the amounts of **radionuclides already authorized**, the authorized user shall file Form RS-11 with the Radiation Safety Program for subsequent review and approval by the RSO/ARSO and the RSC.

3.3.3 Changes in Research Protocols

For major changes in research protocols under an existing authorization, the authorized user shall file Form RS-11 together with the new proposed protocol with the RSP for subsequent review and approval by the RSO/ARSO and the RSC.

3.3.4 Addition of Laboratory

To add a new laboratory to an authorization, the Authorized User should file Form RS-11 with the RSP or provide the equivalent information in writing or electronic mail. A review of the laboratory will be made by the RSP.

3.3.5 Decommissioning a Laboratory

To decommission a radioactive material laboratory, the Authorized User or department head or his/her designate should inform the RSP in writing requesting removal of laboratory

from the authorization. A review and decommissioning effort will then be conducted by the RSP.

3.3.6 Temporary Job Sites

Temporary job sites will be short term applications with a typical duration of less than one week. All temporary job sites must be approved by the RSC and RSO/ARSO before the use or transport of the radioactive material to the temporary job site. No leak tests and instruments calibration services will be performed at a temporary job site.

As described in the RSP Guidance Document entitled "Use of Radioactive Material at Temporary Job Sites", the RSC will issue authorization to use radioactive material at temporary job sites based on the specific protocol, radionuclide, physical form, and user experience. Temporary Job Site Authorization will be considered by the RSO/ARSO for currently approved Authorized Users only.

3.4 Absence of Authorized User

3.4.1 Temporary Absences

For temporary absences from the UTHealth Houston, an Authorized User may designate another investigator on the project staff to supervise the project. Alternatively, the Authorized User may request in writing assistance from the RSO and the RSC in designating an alternate Authorized User, or the project may be tendered temporarily inactive.

For temporary absences from the UTHealth Houston exceeding two months, an Authorized User or the department head should report the absence to the RSO so that the need for a replacement may be explored with the RSC and the Authorized User, or so that the project may be discontinued.

3.4.2 Permanent Absence

In the situation where the authorized user becomes permanently unavailable to the project, either through prolonged absence or departure from UTHealth Houston, written notification should be submitted to the RSP so that appropriate action can be taken by the RSC.

3.5 Discontinuation of the Authorization or Relocation of a Project

The RSP should be notified before termination of an authorization or of vacating a laboratory. Rooms and equipment are to be decontaminated, radionuclides properly disposed or transferred, and all records closed. After conducting surveys to ensure that the area is free from contamination and after checking the necessary records, RSP personnel will conduct a decommissioning survey and remove signs and labels from rooms and apparatus (See Section 9.4).

3.6 Periodic Review and Renewal of Authorization

Authorizations issued by the RSC for the use of radiation sources will be reviewed by the RSP and safety professionals within EH&S. The purpose for such reviews is to provide for renewal of the authorization if the investigation is continuing, to determine if any of the conditions of the authorization have significantly changed, and to verify the authorization information on file with the RSP. This authorization review is typically performed either in conjunction with the semiannual audit schedule or semiannually between the in person semiannual audits outlined in Section 9 Laboratory Safety Audits by EH&S for the active radioactive material use permits.

3.7 Use of Radioactive Material in Animals

3.7.1 General Requirements

Before beginning any experiment involving the use of radioactive materials in animals, the principal investigator must:

A. Be an authorized user of radioactive materials.

B. Complete Form RS-07, "Application for Radioactive Material Use in Animals," and submit it to the RSP. Upon approval, a copy of the approved RS-07 or an approval letter must be submitted to the Animal Welfare Committee with applicable protocols and/or changes. Researchers should also submit Animal Welfare Committee protocol(s) in accordance with AWC requirements.
C. The Center for Laboratory Animal Medicine and Care (CLAMC) requires sufficient notice to enable preparation of the facility before actual use of radionuclides in animals to be housed in the CLAMC. This notification is not required for animals housed within the Authorized User's laboratories.

Investigative procedures involving animal systems vary widely as do applicable safety techniques. The information provided in Form RS-07 will enable both the CLAMC and the RSP to formulate necessary measures and to assist the Authorized User in effecting these measures.

3.7.2 Rules for Using Radionuclides in Animals

A. The areas that animals are kept should be posted in accordance with Section 8.4.
B. Cages and pens should bear labels specifying: the radionuclide, quantity and date administered, ambient radiation levels, and the names of the responsible individual and principal investigator. These cages and pens should be separated from those housing non-radioactive animals.
C. Ventilation should be adequate to handle possible evolution of airborne radioactivity. This may, in some instances, require the use of a fume hood or self-contained controlled environmental systems.
D. Animal excreta should be treated, handled, and disposed as radioactive waste, as appropriate. Also, biologically active agents must be considered during waste disposal.
E. Disposal methods for carcasses or other animal remains should be approved by the RSP, and executed by the EPP.
F. Animal caretakers should be adequately instructed and trained by the authorized user, principal investigator, CLAMC staff or Radiation Safety Program with respect to general and specific handling procedures, dose levels, occupancy time limits and other special conditions specific to the radiation use in animals' protocol.

3.7.3 Radiation Monitoring in Animals

The principal investigator is responsible for overall radiation safety of the project, including but not limited to:

A. Radiation monitoring of the animal(s), cages, and/or the actual procedure when it is performed, pursuant to conditions of the protocol outline in Form RS-07.
B. Analytical determination of radioactivity in urine, feces and bedding (if required).
C. Labeling all cages containing radioactive animals. Tags for this purpose showing the radionuclide, the activity (in μCi or mCi) and the date are available from RSP.

3.7.4 Radioactive Animal Waste Disposal

All animal remains, *i.e.*, viscera, tissue, serum, or other fluids, and the carcass, containing radioactive material should be disposed as follows:

A. The carcass and associated waste should be double bagged in a thick mil plastic carcass bag.
B. Absorbent material should be added to the bag.
C. The bag should then be secured and labeled with a radioactive waste disposal tag identifying the radionuclide(s), activity, date, authorized user, laboratory number and

biological hazard if applicable.

D. The bag and contents should then be placed into an appropriately labeled freezer for radioactive waste. Depending on your location, you will either call EPP at 713-500-5837 for radioactive waste pick-up or place in the appropriate biological AND radioactive waste freezer for animal carcasses. For the appropriate method for your location, consult EPP at 713-500-8100 or online at https://www.uth.edu/safety/environmental-protection/hazardous-waste-disposal-procedures.htm and https://www.uth.edu/safety/radiation-safety/radioactive-waste-alcove-locations.htm.

3.8 Authorization to Use Radioactive Material in Humans

All use of radioactive materials in humans must be reviewed by the RSC. If research, the study must first be submitted to the Committee for the Protection of Human Subjects for research purposes and to the U.S. Food & Drug Administration (U.S. FDA) if the radioactive material product is not an existing U.S. FDA approved radioactive material product and/or FDA approved use of that product in humans for their review and approval of the Investigational New Drug (IND). Form RS-12 must accompany documents to the other committees and must be forwarded to the RSC. All users must also be authorized by the RSC after filing an application as given in Section 3.2 above.

To qualify for use of radioactive materials in humans, a UTHealth Houston physician shall meet the requirements of *25 TAC 289.256(l)* available at: http://www.dshs.texas.gov/radiation/laws-rules.aspx. Additionally, see https://www.dshs.texas.gov/radiation/ram/add-physician.aspx. Contact the Radiation Safety Program for further details.

3.8.1 Radionuclide Generator Use

The use of radionuclide generators involves special precautions. These include:

A. Generator users should wear an extremity monitor due to the high potential for personnel dose.
B. Manufacturer's instructions should be strictly adhered to in the installation and operation of the generator.
C. A portable survey meter capable of measuring the appropriate types and energies used in the laboratories should be available.
D. Each generator should be tested for breakthrough in accordance with the manufacturer's prescribed method.
E. Shielded containers, shielded syringes, tongs, forceps or other suitable remote handling devices should be used whenever feasible during generator eluant (product) collection, storage, processing and transport.
F. Certain generator(s) (e.g. Rb Generator) may require additional documented training by the users, shippers and receivers of the generator and the Radiation Safety Officer.

3.8.2 Report and Notification for Eluate Exceeding Permissible Mo-99, Sr-82 and Sr-85 Concentrations

A. UTHealth Houston representatives will notify by phone to 512-458-7460 and the generator distributor within seven calendar days after discovery an eluate exceeded the permissible concentrations at the time of generator elution. The report must include manufacturer, model number, and serial number (or lot number) of the generator; the results of the measurement; the date of the measurement; whether dosages were administered to patients or human research subjects, when the distributor was notified,

and the action taken.

B. The RSO will submit a follow-up written report within 30 days after the discovery of an eluate exceeding the permissible concentration at the time of generator elution.

3.9 Application to Obtain a Radiation-Producing Device

Any person planning to obtain or construct a radiation-emitting device, including X-ray machines, electron microscopes and analytical X-ray equipment, should submit the following information to the RSP before obtaining the device:

A. A description of the device. Specify the types, energies and levels of radiation anticipated, model number, and manufacturer.
B. Indicate typical energies, beam currents, work load (*i.e.*, hours per week), and a description of how the device will be used.
C. Make available to all operators the operating and safety procedures. All operators shall indicate by signature that they have read the operating and safety procedures.
D. When practicable, a sketch of the facility showing adjacent rooms. Include shielding specifications (including calculations) and beam directions.
E. Indicate portable monitoring instruments that are available. Each project is expected to provide any necessary survey instruments.
F. A brief resume of the pertinent training and experience of the persons responsible for the equipment operation.

Radiation Safety will review the proposed plans and facilities for safety and compliance with regulations and will evaluate the need for and type of radiation badges required.

All radiation-producing machines (except electron microscopes) shall be registered with the Radiation Control Program. RSP registers such machines on behalf of the UTHealth Houston. Each possessor of such a device is required to notify the RSP regarding the machine location.

Under some circumstances, a device may be tagged by Radiation Safety to prevent its use. No attempt to energize or otherwise use the device should be made without prior notification of and approval from the RSP.

4. Procurement, Inventory, and Transfer of RAM

4.1 Ordering Radioactive Material

After authorization for the use of radioactive materials is issued by the RSC, the Authorized User may purchase radionuclides within the scope of that specific authorization.

All acquisitions of radioactive materials require approval from the Radiation Safety Program. The Authorized User must notify the RSP of the intended order or receipt. This is accomplished by completing the information needed for a radioactive material order within the University purchasing system (e.g. Coupa) or completing the **RADiation MATerial** (RADMAT) request Form and submitting via electronic mail to radsafe@uth.tmc.edu.

The following *Ship To* address should be used for radioactive material orders:

UTHealth Houston
Radiation Safety Program, EH&S
6431 Fannin, CYF G102, Cyclotron Building
Houston, TX 77030
Attn: (*Primary Investigator*)

To maintain inventory control the requisition should contain this pertinent information:

Requestor Name:			
Authorized User:			
Radionuclide:		Compound:	
# of Vials or Units:		Activity (mCi) per vial or unit:	mCi
Total activity (mCi) per shipment:	mCi	Vendor Name:	
Contact Person:		Phone:	
Department:			
Please indicate the building and one of the room numbers that the radiation will be stored in:			
		Building Room:	
Additional Information:			

Submit this information to radsafe@uth.tmc.edu. For questions, call 713-500-5840.

The RSP approves the requisition if the Authorized User identified on the order has an active authorization number and meets the conditions of the sublicense agreement. The RSP will ensure that the total on-hand radioactive material inventory for the Authorized User remains within the activity limits authorized by the RSC.

4.1.1 Order Approval

Each supplier of radioactive material is required by state and federal regulations to validate the UTHealth Houston license to possess and to use such material. The RSO, ARSO or RSP will arrange for copies of the broad license to be made available to suppliers. If a copy is needed by a new or prospective supplier, the Authorized User must advise the RSP which will in turn forward a copy to the supplier.

The radioactive material requested by the Authorized User will be approved pending activity limit verification by the RSP (e.g. possession, shipment, or annual limits). Following this approval, the Authorized User may place the order with the radioactive material vendor.

4.2 Receipt of Radioactive Material

Radioactive material shipments are reviewed and processed through the Radiation Safety Program. Packages are inspected for contamination in accordance with 25 TAC §289.202 available at http://www.dshs.texas.gov/radiation/laws-rules.aspx. Inspection information is recorded on the Radioactive Material Package Receipt and Disposal Form (Form RS-05). After determination that the external surfaces of secondary containers are not contaminated, applicable radioactive material markings will be defaced or obscured. Notification is relayed to the listed contact person that the material has arrived and that it should be picked up at the earliest opportunity. To make special arrangements to pick up a shipment, call the RSP at 713-500-8100. Radioactive material for use in buildings other than MSB or MSE will be delivered to the user by the RSP. Laboratory personnel will sign, date, and take possession of the inventory form upon receipt of the package. This form will be maintained by the laboratory personnel.

In special circumstances, radioactive material shipments may be received directly at laboratories. If this is the case, arrangements must be made in advance with the RSP for the

appropriate receipt processing and training.

4.3 Radioactive Material Inventory Requirements

4.3.1 Package Inspection Report and Radionuclide Inventory Form

Each authorized user should have a record of all radioactive material available for review. Such records cannot be maintained solely by the RSP because, by their nature, these records represent a dynamic condition of new supply, use, disposal and radioactive decay. The individual Authorized User should keep a current inventory of all radioactive materials. These records should be kept in a form that permits convenient, periodic review. The Radioactive Material Package Receipt and Disposal Form (Form RS-05) for each approved radioactive material order or receipt will be provided by the RSP with the radioactive material package.

The following information is required for each isotope and must be recorded:

A. Date of use or disposal.
B. Activity used or amount disposed. Realistic and practical estimates are acceptable. The person performing the protocol/disposal must also be noted on the form.
C. Disposal tags from the EPP should be completed to track disposal of material. For disposal tag supplies call 713-500-5837.

The disposal sheet (Form RS-05) or "use log" is intended to monitor radioactive material disposal for each vial received at UTHealth Houston. Environmental Health & Safety (EH&S) personnel will check the inventory records during routine laboratory evaluations. The inventory sheets or equivalent should be available for review by the EH&S or by representatives of the Texas Department of State Health Services.

When the radioactive material is fully disposed, a copy of the completed inventory/disposal record may be retained by the laboratory. The original should be forwarded to the RSP, CYF G102 or fax to 713-500-5841. The laboratory copy should be retained for a period of at least 12 months following complete disposal.

4.4 Transfer of Radioactive Material

An Authorized User may transfer radioactive materials to another Authorized User within UTHealth Houston's permit provided the recipient is authorized for the radioactive material and quantities involved. The RSP should be notified before the transfer, and will generate a new inventory form (RS-05) for the recipient. The transferring user records the transfer on their inventory form and this form is submitted to the RSP. The RSP must be contacted prior to the transfer of radioactive material from an Authorized User on UTHealth Houston's permit to another Authorized User on another Authorized Radioactive Material License to ensure the appropriate documentation and rules are followed. Often, this transfer may also require the shipment of radioactive materials.

4.5 Shipment of Radioactive Material

Shipment of radioactive material must be approved by the RSP. Shipment of any radioactive materials to an outside institution requires verification by the RSP that the receiving institution is licensed to receive the materials. Additionally, the shipper must be trained in accordance with the appropriate U.S. Department of Transportation (DOT) regulations. Generally, the RSP will act as the shipper. Verification may follow any of the methods listed in 25 TAC § 289.252. Generally, this means that a copy of the license authorizing the recipient to possess the source must be on file in the RSP before shipping the source.

All regulated radioactive materials and devices will be shipped from this institution in accordance with the DOT regulations and UTHealth Houston packaging and shipping policy.

- Licensed radioactive materials must not be removed from UTHealth Houston

without the specific approval of the RSP.
- Each package to be transported or shipped from UTHealth Houston will be inspected for safety and compliance with transport regulations by a designated representative of the RSP or the individual will be appropriately trained.
- All costs for inspection and transport or shipping will be assessed to the originating department or operating unit.

Inspection and transport/shipping records will be maintained by the RSP and for an interval dictated by the DOT and other pertinent regulations.

5. Disposal of Radioactive Waste

All radioactive wastes stemming from UTHealth Houston research laboratories shall be disposed of in such a way as to minimize the hazard to the health of personnel, to the value of property or to the community. Adherence to the recommendations and requirements established in this section will achieve these goals, as well as ensure compliance with the *25 TAC§289*. The Environmental Protection Program (EPP) within Environmental Health & Safety (EH&S) is charged with the responsibility of collection, treatment, and disposal of radioactive wastes, under the ultimate direction of the RSO. Reports, procedures, and records pertaining to sources of radiation are generated under the supervision of the RSO/ARSO, and are submitted to the RSC.

For assistance in matters relating to waste disposal during normal working hours, call the EPP at 713-500-8100 or the RSP at 713-500-5840. In an emergency, dial 911. For non-emergencies or dispatch, call UT Police at Houston (UT Police) at 713-792-2890.

5.1 Types of Radioactive Waste

A. **Solid:** Solid materials which have become contaminated during research protocols. These may include gloves, absorbent paper, pipette tips, etc.
B. **Liquid:** Liquid materials which have become contaminated during research protocols. These include solutions, buffers, rinses, etc.
C. **Liquid Scintillation Vials:** Liquid or other media mixed with liquid scintillation fluid in small vials typically 1 mL to 20 mL in volume. Liquid scintillation vials are often generated from removable radiation contamination surveys.
D. **Biological/Animal Carcass:** Biologically active or remains of animals which have been subjected to radioactive material protocols. These include animal carcasses, pathological waste, microbiological waste, etc.
E. **Sharp/Broken Glass:** Sharp objects or broken glass which have become contaminated during research protocols. These may include needles, razor blades, pasteur pipettes, broken glass, etc.

5.2 General Requirements and Responsibilities

Each Authorized User must ensure, prior to the procurement of any radioactive materials, that a satisfactory waste disposal method exists or is developed.

A. Each Authorized User should accurately identify, quantify and label the types, quantities, and forms of radioisotopes that are placed in the radioactive waste generated under their authorization.
B. Radioactive waste containers in the lab should be stored as close to the work area as possible to minimize the probability of spillage during the transfer to the containers.
C. Unattended radioactive waste containers are prohibited from being stored in unrestricted areas.

D. Radioactive waste containers should be closed when not in use.
E. Radioactive waste containers should be posted with a "Caution Radioactive Material" label.
F. When handling or transferring radioactive waste the individual should wear proper personal protective equipment.
G. Radioactive wastes containing carcinogens, biological hazards, sharps, or acutely hazardous chemicals must be inactivated, if possible, and packaged to present minimal hazards to EPP personnel.
H. Radioactive solid waste disposed in the public type I landfill will be surveyed before disposal in accordance with internal procedures. Due to the complicated nature of the radioactive materials being disposed of, UTHealth Houston will rely on the Public Landfill screening level of 50 µrem at the vehicle's surface as indication of acceptable levels for release.

5.3 Dry Solid Waste Disposal

Dry solid waste consists of items that have come into contact with radioactive materials and have less than 3% free liquids. Such items include, but are not restricted to, absorbent padding and other protective coverings, latex/nitrile gloves, tubing, glassware, plastic, paper and metal. This waste is discarded by the generator into segregated containers at various locations throughout the UTHealth Houston properties.

A. Solid radioactive waste is segregated at the generation point (e.g. laboratory or clinic) into the following categories.
   1. **Radioactive waste with half-life of < 300 days**
   2. **Radioactive waste with half-life of > 300 days**

Waste segregation is facilitated with labeled containers supplied by the EPP.

B. The waste should be placed in bags and securely sealed. Bags and tie wraps are provided by the EPP.

To dispose :

C. A completed radioactive waste disposal tag is attached to the waste bag identifying the laboratory, radionuclide, date, and activity of the waste.
D. Transport the waste bag and place it in one of the segregated containers located in the radioactive waste alcoves. A list of radioactive waste alcoves is available through the EPP online at https://www.uth.edu/safety/radiation-safety/radioactive-waste-alcove-locations.htm. Keys to unlock the radioactive waste alcoves are available through Locksmith Services within Remodeling Services (713-500-4774) to authorized users.

5.4 Liquid Radioactive Waste Disposal

Liquid radioactive waste consists of aqueous or organic waste effluents generated in the course of research activities. This waste is collected from each laboratory location and disposed through EPP procedures. Guidelines for the proper handling, storage, and disposal of liquid radioactive waste follow:

A. The first and second rinses from contaminated glassware should be disposed into the liquid radioactive waste. Subsequent rinses can be disposed of into a designated sink labeled with appropriate cautionary information.
B. Radioactive liquid waste should be segregated *by radionuclide* (e.g. ^{32}P and ^{35}S in different waste jugs) and the following categories:
   1. Radioactive Liquid Waste - **Aqueous**
   2. Radioactive Liquid Waste - **Organic** (>10% hydrocarbons)

C. The waste should be readily soluble or readily biologically dispersible material. Corrosive or reactive wastes should be chemically neutralized as part of the experimental procedure.
D. The waste should be placed in capped plastic containers. Glass containers are not recommended for storage of liquid waste, unless the liquid waste will react with the plastic container.
E. The waste should be stored in a remote but accessible location in the laboratory. The container and storage area should be marked with a radioactive material warning label, and appropriate shielding may be used to limit dose rates to personnel working in the laboratory.
F. Containers should be closed and placed in secondary containment to prevent spills.

To dispose:

G. When the container is 90% full, a radioactive material disposal tag/label identifying the laboratory, the isotope, radionuclide, activity, date and other pertinent information should be completed and attached to the container.
H. Contact the hazardous waste line (713-500-5837) for collection by EPP personnel. EPP personnel will provide replacement containers at this time.

In special cases, permission can be granted to authorized users for disposal of radioactive liquid waste in individual laboratories. Prior to approval, the Authorized User should supply a specific set of procedures to the EPP. The procedures should include but not be limited to the following information:

A. Measures to ensure compliance with 25 TAC §289.202 (ggg)(2) – Table 3 Concentration for Release to Sanitary Sewer, and other applicable local, state and federal regulations regarding the release of fluids into the sanitary sewer.
B. A method for reporting all pertinent disposal information (e.g. radionuclide, activity, dates, and volumes disposed) to the EPP.

5.5 Liquid Scintillation Vial Waste Disposal

Liquid scintillation vial waste is waste generated from the use of liquid scintillation counting methods. This waste is disposed by the generator into segregated containers located at various locations throughout the UTHealth Houston. Guidelines for the storage, collection, and disposal of liquid scintillation vial waste follow:

A. Scintillation vials should be segregated at the point of generation into the following categories:
    1. **Scintillation vials containing ^{3}H, ^{14}C and/or ^{125}I**
    2. **Scintillation vials containing any other radionuclide (e.g. ^{32}P, ^{35}S, ^{22}Na)**

To facilitate the segregation process, labeled containers are available by contacting the EPP at 713-500-5837.

To dispose:

B. Liquid scintillation vials should be placed in a plastic bag and securely sealed. Bags and tie wraps are available in the radioactive waste alcoves.
C. A completed disposal label should then be attached to the bag, identifying the laboratory, radionuclide, date, and activity of the waste.
D. The bag should then be placed into one of the segregated containers located in the radioactive waste alcoves.

5.6 Biological and Sharp Waste

5.6.1 Biological Waste

Radioactive biological waste is defined as animal carcasses and associated waste, pathological waste, microbiological waste, and sharps that have come into contact with radioactive materials. Guidelines for the storage, collection, and disposal of radioactive biological waste follow:

A. All radioactive biological waste should be first segregated into the following categories:
   1. **Radioactive waste with half-life > 300 days**
   2. **Radioactive waste with half-life < 300 days**
B. All biological waste should be double-bagged in thick mil opaque bags and sealed with tape or tie wrap. Absorbent should be placed in bags containing animal carcasses or free liquids. In MSB building, bags and absorbent are located adjacent to the animal freezer in MSB B.304. The bag should be sealed with tape or a tie wrap.
C. A biological and radioactive waste disposal tag should then be attached to the bag identifying the type of waste, radionuclide, activity, date and other pertinent information. **Waste that contains an infectious agent should have the name of the infectious agent clearly identified on the biological waste label!**
D. Call the hazardous waste line (713-500-5837) for collection of biological wastes. Animal carcass waste may be transported by laboratory staff to a designated freezer.
E. When possible, infectious wastes should be treated prior to disposal.

5.6.2 Radioactive Sharp Waste

Sharps (needles, razor blades, pasteur pipettes, and broken glass, etc.) contaminated with radioactive materials shall be placed in an approved sharps container prior to disposal. The sharps container should be labeled with a "Caution Radioactive Material" label while in use, and a radioactive waste label completed prior to contacting EPP for pickup. Sharps containers are available through the EPP.

5.7 Equipment Releases

Equipment containing a radioactive source (e.g. liquid scintillation counters, gas chromatographs, spectrometers) may have the source removed or may be transferred to an appropriately licensed recipient. Equipment contaminated by radioactive material (e.g. refrigerators, centrifuges, water baths) must be properly decontaminated. Guidelines for the transfer of equipment follow:

A. For equipment that has come into contact with radioactive materials, investigators shall decontaminate equipment and conduct the appropriate surveys to ensure that any contamination is below the release for unrestricted use limits stated in *25 TAC*. For unrestricted release of equipment, the residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year (*25 TAC § 289.202(ddd)*).
B. For equipment that contains a radioactive source, the EPP will make arrangements to extricate the source and arrange for the proper disposal or transfer to an appropriately licensed recipient.
C. Prior to transfer of the equipment, the EPP should be contacted at 713-500-8100. A confirmatory survey will then be conducted and approval for the transfer will be granted.

5.8 Airborne Releases of Radioactive Material

Prior to utilizing gaseous radionuclides (i.e. radioactive noble gases, etc.), special approval must

be obtained from the RSP and the EPP. This special approval is not necessary for releases occurring from volatilization, heating, spraying, etc. Prior to approval, the Authorized User should supply procedures to the EPP which identifies:

A. Measures to ensure compliance with *25 TAC 289.202 (ggg)(2)*.
B. A method for reporting all pertinent disposal information (e.g. radionuclide, activity concentration, chemical form, date) to the EPP.

5.9 Radioactive Waste Minimization and Source Reduction

Waste minimization and source reduction is the principle of reducing radioactive waste generated by controlling and reducing the amount and volume of source material.

1. When possible, non-radioactive materials should be substituted for radioactive materials.
2. When possible, radionuclides with short half-lives should be substituted for those with long half-lives.
3. Radioactive waste should be segregated from non-radioactive waste at the point of generation.
4. Secondary containment should be used when handling, storing, or transporting liquid waste.
5. Non-bulky materials should be used when cleaning spills.
6. Compatible materials should be used in experiments.
7. Microscale techniques should be used when possible.
8. New lab personnel should be indoctrinated and trained in proper methods for waste minimization in the lab.

6. Limitation and Minimization of Radiation Exposures

Harmful effects of ionizing radiation were recognized very soon after the discovery of x-rays and of naturally occurring radionuclides late in the last century. These were visible external lesions resulting from rather massive radiation doses. We still see some of these lesions but, with rare exceptions, they are confined to persons receiving radiotherapy. With the high-energy radiotherapy sources now available, even these are becoming uncommon.

On the other hand, research and observations during the intervening years have revealed more subtle deleterious effects from smaller radiation doses. The consensus of modern thought on the subjects of radiation risk and radiation safety is contained in the following quotations from a 1962 report of the United Nations Committee on the Effects of Atomic Radiation:

> It is clearly established that exposure to radiation, even in doses substantially lower than those producing acute effects, may cause a wide variety of harmful effects including cancer, leukemia, and inherited abnormalities, that in some cases may not be easily distinguishable from naturally occurring conditions, or identifiable as due to radiation alone. Because of the available evidence that genetic damage occurs at the lowest levels as yet experimentally tested, it is prudent to assume that some genetic damage may follow any dose of radiation, however small. The committee therefore emphasizes the need that all forms of unnecessary radiation exposure should be minimized or avoided entirely, particularly when the exposure of large populations is entailed; and that every procedure involving the peaceful uses of ionizing radiation should be subject to an appropriate, immediate and continuing scrutiny in order to ensure that the resulting exposure is consistent with the necessity of the value of the procedure.

Or as stated by the Federal Radiation Council:

> The establishment of radiation protection standards involves a balancing of the benefits to be derived from the controlled use of radiation sources against the risk of radiation exposure. The principle is based upon the position adopted by the Federal Radiation Council that any radiation exposure of the population involves some risk, the magnitude that increases with the exposure.

A well-written, easily understandable discussion of the basis for establishment of radiation dose limits can be found in the U.S. Nuclear Regulatory Commission *Regulatory Guide 8.29 Instruction Concerning Risks from Occupational Radiation Exposure* available online at http://www.nrc.gov in the electronic reading room or at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/occupational-health/rg/division-8/division-8-2.html. For assistance in obtaining a copy, contact the RSP at 713-500-8100.

These cautionary statements by the United Nations Committee and the Federal Radiation Council might be summarized as:

A. Ionizing radiation is undetectable by the human senses. This can be very important in attitudes toward radiation and safety.
B. It is assumed that there is no "safe" dose of radiation. Any exposure involves some degree of risk.
C. There may be a long latent period between exposure and manifestation of effects up to decades for somatic effects, perhaps generations for genetic effects.
D. Radiation apparently induces few unique biological effects. Thus, except for massive acute exposures, causal relationships between radiation exposure and deleterious effects can be established on a statistical basis only.

6.1 The ALARA Principle

In more recent years, a philosophy of control of radiation dose called As Low As Reasonably Achievable (ALARA) has become an integral, functioning part of radiation protection programs. Radiation safety programs have traditionally been most conservative in minimizing radiation exposure to workers, and ALARA is simply a more formal commitment to this basic principle of radiation protection. All uses of radioactive materials and radiation-producing machines at UTHealth shall be conducted with ALARA as a guiding principle.

The ALARA Action Level at UTHealth is defined as 2.5% of any applicable occupational limit. UTHealth employees, residents or students may work with fluoroscopy or higher activities in radiation therapy on other radiation permits. Some of these individuals routinely working on other radiation permits within certain areas are anticipated to have higher doses, thus a higher ALARA investigation level (Resident Group) is set for this population at 10% and 30% of the annual dose limit. To this end, a personnel dosimeter reading exceeding their ALARA level should be investigated by the RSP. This investigation will examine workload and protocol changes, dosimeter placement variations, personnel dose trends, or possible methods of dose minimization for future protocols. ALARA investigations are triggered for occupational doses above their ALARA action level in a single monitoring period.

6.2 Radiation Dose Limits

6.2.1 Occupationally Exposed Adults

Table 1: Annual occupational dose limits and ALARA action level for adult radiation workers.

Applicable Dose Limit	Annual Limit Rem	ALARA Action Level (General Worker) Rem	ALARA Action Level 1 (Resident Group) Rem	ALARA Action Level 2 (Resident Group) Rem
Total Effective Dose Equivalent (TEDE)	5	0.125	0.500	1.500
Total Organ Dose Equivalent (TODE)	50	1.250	5.000	15.000
Skin Dose Equivalent (SDE)	50	1.250	5.000	15.000
Extremity Dose Equivalent	50	1.250	5.000	15.000
Eye (Lens) Dose Equivalent (LDE)	15	0.375	15.000	4.500

6.2.2 Limits for Individual Members of the Public

The dose limits for individual members of the public are described in *25 TAC §289.202*. These regulations state that each licensee will limit operations such that:

A. The total effective dose equivalent to members of the public does not exceed 0.1 rem in a year;
B. The total effective dose equivalent to members of the public from exposure to radiation machines does not exceed 0.5 rem per year; and
C. The dose in any unrestricted area from licensed/registered external sources does not exceed 0.002 rem in any one hour.

6.2.3 Occupational Dose Limits for Minors (Radiation Workers under Age 18)

The annual occupational dose limit for minors is 10% of the annual occupational dose limits specified for adult workers in *25 TAC §289.202* (Section 6.2.1 of this document).

6.2.4 Occupational Dose Limits for a Declared Pregnant Worker

A "declared pregnant woman" means a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception. *25 TAC §289.202* provides specific guidance for dose limits to the fetus/embryo.

For additional information regarding prenatal radiation dose risks to the fetus, foundation for established dose limits, and responsibilities of the female radiation worker, the U.S. Nuclear Regulatory Commission published *Regulatory Guide 8.13 Instruction Concerning Prenatal Radiation Exposure* available at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/occupational-health/rg/division-8/division-8-1.html, which is available from the Radiation Safety Program.

6.2.4.1 Dose Limits for the Embryo/Fetus

If a woman declares her pregnancy, the licensee shall ensure that the dose to the embryo/fetus during the entire pregnancy, resulting from occupational exposure of a declared pregnant worker, does not exceed 0.5 rem (5 millisieverts). If the worker chooses not to declare pregnancy in writing, the occupational dose limits specified in *25 TAC §289.202* are applicable. In addition, efforts shall be made to avoid substantial variation above a uniform monthly exposure rate to a

declared pregnant worker. The National Council on Radiation Protection and Measurements recommended in NCRP Report No. 91 "Recommendations on Limits for Exposure to Ionizing Radiation" (June 1, 1987) that no more than 0.05 rem (0.5 mSv) to the embryo/fetus be received in any one month.
If, by the time the worker declares pregnancy, the dose to the embryo/fetus has exceeded 0.45 rem (4.5 millisievert), the embryo/fetus is limited to 0.05 rem (0.5 millisievert) for the remainder of the pregnancy.

6.2.4.2 Assignment of Dose to the Embryo/Fetus

The dose to the embryo/fetus shall be taken as:

A. The dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant worker; and
B. The dose that is most representative of the dose to the embryo/fetus from external radiation, that is, in the mother's lower torso region.
    1. If multiple measurements have not been made, assignment of the highest deep dose equivalent for the declared pregnant worker shall be the dose to the embryo/fetus; or
    2. If multiple measurements have been made, assignment of the deep dose equivalent for the declared pregnant worker from the individual monitoring device that is most representative of the dose to the embryo/fetus shall be the dose to the embryo/fetus. Assignment of the highest deep dose equivalent for the declared pregnant woman to the embryo/fetus is not required unless that dose is also the most representative deep dose equivalent for the region of the embryo/fetus.

6.3 Dose Minimization

In accordance with the ALARA principle, all procedures, protocols, examinations, and tutorials shall be conducted in a manner which minimizes the radiation dose to workers and the general public.

6.3.1 Engineered Control of Dose Minimization

Radioactive material or radiation-producing machines are to be used or stored only in those rooms or areas that have been approved by the RSP. Research laboratories for such use must meet the following requirements:

6.3.1.1 Facility Requirements

A. A means of controlling access and securing the room when no authorized individual is in the area. This condition intends to prevent accidental exposure of a member of the general public.
B. Radionuclide experiments that potentially generate aerosolized radioactive material should be performed under conditions of controlled ventilation. In general, ventilation control may be accomplished through the use of negatively-pressured work cabinets (e.g. chemical fume hoods). The operating parameters of the ventilating cabinets will follow manufacturer specifications. Hoods found not meeting these specifications will not be certified for radioactive material use, and lab personnel will be informed of the need for alternative ventilation.
C. The air handling system should maintain the laboratory at a negative pressure relative to adjacent occupied rooms or hallways. Exhausted air with the potential for airborne contamination should be adequately filtered to minimize radioactive material released to the environment. Further, care should be taken to avoid air intake locations in

close proximity to exhaust locations for potentially contaminated air.

D. All radioactive material laboratories shall be designed or shielded in accordance with *25 TAC §289.202*, dose limits for individual members of the general public.
E. It is the responsibility of the authorized user to provide adequate shielding to ensure that all personnel radiation exposures are kept as low as reasonably achievable.
F. Fire suppression and alarm systems should be designed to minimize the spread or release of radioactive materials in the event of a fire.

6.3.2 Administrative Control of Dose Minimization

The engineered controls specified in the design of the radioactive material laboratory may be augmented through additional administrative controls. These may take the form of training, procedures, or supplemental Authorized User conditions or restrictions.

6.3.2.1 Control of Dose from External Sources

Sources of radiation external to the body account for the overwhelming majority of radiation dose at UTHealth. Therefore, procedures and policies should be in place to administratively control external radiation exposure.

A. **Time** - Decreasing "exposure time" reduces personnel dose linearly. To this end, "dry-runs" of critical steps involving radioactive material in a new protocol may help identify problems, avoid errors, and speed the completion of the task. In general, a task should be performed expediently, but not hastily.
B. **Distance** - Increasing the distance between personnel and the radiation source is an effective means of reducing dose. The radiation dose rate follows the "inverse square law". Simply put, the dose rate drops by the inverse square of the distance. Thus, moving from 1 meter to 3 meters reduces the dose rate by a factor of nine. For this reason, remote handling devices (e.g. tongs, tweezers, or other long-handled tools) can significantly reduce personnel dose, especially to the hands.
C. **Shielding** - Shielding a source of radiation generally reduces the radiation levels around the radioactive source. In particular, shielding should be utilized for stored sources (e.g. the primary vial or high-activity radioactive waste). For the majority of biomedical research uses, the blue or gray plastic shield supplied by the manufacturer fulfills this reduction schema. But, a significant fraction of the activity will concentrate in the radioactive waste. Use additional shielding around radioactive waste receptacles, when needed. Shielding is required when radiation levels exceed 2 mrem / hr in an unrestricted area.
    1. ***Beta-emitting sources*** *(β)* - most effectively shielded using low atomic number shielding material (e.g. hydrogen, oxygen, and carbon). Three-eighths inches of Plexiglas™ is recommended for high-energy beta-particle emitters (e.g. ^{32}P).
    2. ***Gamma-emitting sources*** *(γ)*- most effectively shielded using high-atomic number and high-density materials (e.g. lead, concrete, or iron). Shielding thickness will depend upon the radionuclide, activity, and storage location. Contact the RSP for further information.
    3. ***Alpha-emitting sources*** *(α)*- short range particles in air. Therefore, alpha particles are not considered an external hazard. No shielding is generally required.
D. **Source Reduction** - reducing the activity used in each laboratory protocol will linearly reduce the dose rate. By possessing in the lab only the required activity for each protocol, personnel dose will be minimized.

E. **Source Substitution** - substitution of non-radioactive reagents is recommended to help minimize personnel dose. In addition, the substitution of ^{35}S or ^{33}P for ^{32}P may also help reduce the dose to laboratory personnel.

6.3.2.2 Control of Dose from Internal Sources

The control methods outlined above do not readily apply when considering minimization efforts for internally-deposited radionuclides. The primary control method for internal deposition is *prevention*. Preventing the inhalation and ingestion of radionuclides is the recommended method for internal dose control.

The four major pathways of internal deposition of radionuclides are:

A. **Inhalation** - inhaling airborne radioactive species.
B. **Ingestion** - consuming a contaminated liquid or food.
C. **Absorption** - skin contamination may result in absorption of radioactive material into the blood though the capillary system.
D. **Injection** - direct puncture or piercing of the protective layer of the skin.

Volatile radioactive compounds are defined as those compounds which readily become airborne. Examples of volatile radioactive compounds include ^{125}I and ^{131}I in a NaI solution, tritiated water (HTO), compounds with high-vapor pressure, and powdered radioactive solids. Furthermore, nonvolatile reagents may become airborne when heated agitated, powdered, or treated. Prevention of deposition pathways includes both facility requirements and administrative control procedures. The following guidelines should be used to minimize internal dose to personnel:

A. **Fume Hoods** - A chemical fume hood suitable for radioactive materials shall be used when using high activities of volatile radioactive compounds. Enclosures other than suitable fume hoods must receive *a priori* review and approval from the RSP.
B. **No Smoking, Eating, or Drinking in Laboratories** - To minimize the risk of intake of radioactive materials through the ingestion pathway, consumption in a laboratory area where radioactive materials (excluding sealed sources) are used is prohibited. This includes smoking, chewing tobacco, eating, and drinking. In addition, comestibles, eating utensils, etc. should not be stored where radioactive cross-contamination is likely. Microwave ovens in laboratories where radioactive materials are used or stored should not be used for food preparation.
C. **Use of Protective Clothing** - Personal protective equipment furnishes an initial barrier in protecting against the absorption and injection pathways. This equipment may take the form of disposable gloves, laboratory jackets, long pants, closed-toe footwear, safety glasses and face shield. The majority of skin contaminations observed in an academic research environment may have been prevented through the proper use and application of protective clothing. Therefore, the following limitations are promulgated:
    1. Gloves should be worn when working with unsealed radionuclides.
    2. Laboratory jackets or coats should be worn when the protocol requires the use of unsealed radionuclides.
    3. Protective clothing covering the legs should be worn when performing radionuclide protocols.
    4. Closed-toe footwear should be worn when performing radionuclide protocols.
    5. Face and eye protection are recommended when performing radionuclide protocols.

D. **Proper Handling of Contaminated Sharps** - Sharp objects which are contaminated with radioactive material present an injection hazard. Therefore, personnel should minimize the handling of sharps. Do not recap syringes after completion of the injection. Sharp materials should be handled with thick gloves (e.g. leather or chain mesh) in order to reduce the injection potential. Radiation contaminated sharps should be placed in a suitable sharps container or other container to remove the sharps hazard. The sharps container would then be placed in a radioactive solid waste container.

E. **Respiratory Protective Equipment** - Commitment to use respiratory protection cannot be taken lightly. It is generally advantageous to spend a little more time and money in the design and planning of experimental work in order to eliminate or minimize airborne radioactivity than to rely upon respiratory protection to control worker intake.

The Radiation Safety Program should be consulted for advice in the use of respiratory protection devices, e.g. dust respirators, respirators with chemical absorption capabilities, or supplied air respirators (SCBA). Commitment to such devices can require extensive medical evaluations to qualify a worker for such use, thorough fitting, training and maintenance programs, and must comply with *25 TAC §289.202 (ggg)(2)* Annual Limit on Intake and Derived Air Concentration.

6.4 General Precautions for Contamination Control

The prevention of an internal exposure caused by the entry of radioactive materials into the body, and the prevention of external exposure requires the development and use of sound laboratory techniques. Good housekeeping, good personal habits, and the proper use of equipment are essential ingredients. Typical guidelines for investigators or laboratory personnel using radioactive materials are as follows:

A. Non-essential persons should not be allowed into the laboratory while radioactive procedures are in progress.
B. A portion of the laboratory should be set aside only for procedures involving the use of radioactive materials. Radioactive materials should be handled and used only in this designated work area, and nonessential materials should not be brought into this area. Locate work areas away from heavy traffic or doorways.
C. Work with radioactive materials should be performed rapidly but carefully.
D. Bottles, flasks, tubes, and/or other appliances containing radioactive material should be identified by the proper international radiation warning symbol (Section 8.4 of this document).
E. Exercise deliberate care in handling radioactive materials. Do not splash, splatter, or spill radioactive liquids. Cross-contamination from small radioactive droplets is a major source of radioactive material contamination in an academic research environment.
F. Smoking, eating, drinking, and applying cosmetics is prohibited in the laboratory at all times.
G. Food containers should not be permitted in the laboratory. Refrigerators should not be used for the common storage of food and radioactive materials.
H. The laboratory should be kept clean and orderly at all times.
I. Pipetting radioactive materials by mouth is prohibited at all times. Rubber bulbs, syringes, or mechanical devices shall be used.

J. All transfers and dilutions with a significant potential for inhalation should be performed in functioning exhaust hoods or glove boxes.
K. Work should be planned ahead, and whenever possible, a dummy run should be accomplished to test the procedure.
L. Absorbent paper should cover work benches, trays and other work surfaces where radioactive materials protocols are performed.
M. Rubber or plastic gloves should be worn while working with radioactive materials. Nitrile or alternate appropriate gloves may be substituted if a latex allergy is suspected. For assistance in selecting gloves, contact Environmental Health & Safety at 713-500-8100.
N. When a procedure is completed, and before leaving the laboratory, wash and monitor the hands. (Monitoring means to check for radioactivity using an appropriate survey meter.) Decontamination of the hands may not be easy and may require vigorous and repeated scrubbing. Wash hands with soap in a full stream of water. Use a scrub brush, if necessary, and exercise care not to abrade the skin.
O. Radioactive material in liquid form should be stored and transported in double containers.
P. Primary radioactive material vials should be stored in secondary container, such as the blue, yellow, or gray plastic container used for shipping.
Q. All items of equipment intended to provide features of safety should be checked periodically to ensure that they are providing the safety feature intended.
R. Radioactive material must be stored in an appropriately secure and shielded area.

7. Personnel Dosimetry

The purpose of the radiation dosimetry program is to measure the radiation dose equivalent from occupationally exposed radiation workers at The University of Texas Health Science Center at Houston. The dosimetry results verify and document adherence with the occupational dose limits in *25 TAC §289.202*. An ancillary purpose is the identification of problems and to monitor the efficacy of existing radiation safety measures.
Radiation dose equivalent is received in two general ways:

1. Radiation sources which are external to the worker's body.
2. Radiation sources which are internal to the worker's body.

Consequently, the dose equivalent from these two categories are measured in different manners. The external dosimetry program is administered by the RSP. Insofar, the personnel dosimeters issued by the RSP will be processed by a National Voluntary Laboratory Accreditation Program (NVLAP) dosimetry contractor. The internal dosimetry program is also administered by the RSP. To this end, the internal dose assessment procedures or protocols will be consistent with NCRP and DSHS RCP recommendations.

7.1 External Radiation Dosimetry

A. The RSP should monitor occupational exposure to radiation and supply and require the use of individual monitoring devices by:
    1. Adult radiation workers likely to receive, in one year from radiation sources external to the body, a dose in excess of 10% of the limits in *25 TAC §289.202*;

2. Minors and declared pregnant workers likely to receive, in one year from sources external to the body, a dose in excess of 10% of any of the applicable limits in *25 TAC §289.202*;
3. Individuals entering a high or very high radiation area; and
4. Individuals maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any safety component in the x-ray system is disassembled or removed.

B. The RSP will determine what groups are likely to exceed 10% of any applicable dose limit using all available data. These data may include facilities, equipment, radionuclides, and activities in use.

C. The Authorized User should notify the RSP of protocol changes significantly affecting radiation dose equivalent in the laboratories under their authorization.

D. The ALARA investigation level at UTHealth Houston is defined as 2.5% of any applicable occupational limit. UTHealth Houston employees, residents or students may work with fluoroscopy or higher activities in radiation therapy on other radiation permits. Some of these individuals are anticipated to have higher doses, thus a higher ALARA investigation level (Resident Group) is set for this population at 10% and 30% of the annual dose limit. To this end, a dosimeter measurement in a monitoring period exceeding this ALARA level should be investigated by the RSP. This investigation will examine workload and protocol changes, dosimeter placement variations, or possible methods of dose minimization for future protocols.

E. Radiation dosimeters shall not be deceptively exposed. These devices are an integral safety component and must accurately reflect the worker's true exposure scenario. If a situation arises, please contact the RSP for resolution.
   1. Under no circumstances should a dosimeter assigned to one person be worn by another person.
   2. Dosimeters in storage and not being worn should not be stored near sources of radiation.
   3. Dosimeters should not be exposed to high heat, chemical, or physical insults, including the washing machine.
   4. Dosimeters should not be worn during medical or dental examinations. Medical exposure to radiation is not intended to be recorded on occupational radiation exposure records.
   5. The Authorized User should inform the Radiation Safety Program upon discovery of any misrepresentative dosimeter information.

F. For information regarding the management of personal dosimeters at UTHealth Houston, please contact the RSP.

G. Location and use of individual monitoring devices:
   1. An individual monitoring device used for monitoring the dose to the whole body shall be worn at the unshielded location of the whole body likely to receive the highest exposure. When a protective apron is worn, the location of the individual monitoring device is typically at the collar, outside the apron.
      2. If an additional individual monitoring device is used for monitoring the dose to an embryo/fetus of a declared pregnant worker, it should be located at the waist under any protective apron being worn.

3. An individual monitoring device used for monitoring the eye dose equivalent should be located at the neck or a location closer to the eye, outside any protective apron being worn by the monitored individual.
4. An individual monitoring device used for monitoring the dose to the extremities should be worn on the extremity likely to receive the highest dose which is often the dominant hand. Each individual monitoring device, to the extent practicable, should be oriented to measure the highest dose to the extremity being monitored. In most circumstances, the extremity monitoring device should be worn inside any gloves to minimize the chance of contaminating the device.
5. An individual monitoring device should be worn for the period of time authorized by the dosimetry processor certificate of registration or for no longer than three months, whichever is more restrictive.

H. Any employee likely to receive 10% of any applicable dose limit working with radiation at UTHealth Houston may receive a copy of their dose records upon written request.
I. Upon employment termination, a dose termination report shall be provided to any workers who received dosimetry upon their written request.
J. The assigned deep dose equivalent and shallow dose equivalent shall be for the portion of the body receiving the highest dose.
K. The deep dose equivalent, eye dose equivalent, and shallow dose equivalent may be assessed from surveys, use factors, exposure time calculations or other measurements for the purpose of demonstrating compliance with the occupational dose limits, if the monitoring device was mishandled, destroyed, or lost.
L. The RSP may issue personnel monitors for occupationally-exposed individuals who are not likely to exceed 10% of the dose limits in *25 TAC §289.202*. Personnel monitoring records for these individuals are not subject to the recordkeeping and notification requirements specified in *25 TAC §289.202*.

7.2 Internal Radiation Dosimetry

A. The RSP shall monitor occupational exposure to radiation and shall provide and require the use of internal radiation dose assessments for:
   1. Adult radiation workers likely to receive, in one year, an intake in excess of 10% of the applicable Annual Limit on Intake in *25 TAC §289.202 (ggg)(2)*.
   2. Minors and declared pregnant workers likely to receive, in one year, a committed effective dose equivalent in excess of 0.05 rem (0.5 millisievert).
B. For purposes of assessing committed effective dose equivalent, the RSP shall utilize the following measurements:
   1. Concentrations of radioactive materials in the air or water in the work zone; or
   2. Quantities of radioactive materials in the body; or
   3. Quantities of radioactive materials excreted from the body; or
   4. Any combination of these measurements.
C. In the absence of respiratory protective equipment and intake assessment bioassay measurements, the time-weighted average of the airborne radioactive material concentration should be used as the inhaled radioactive material concentration for the exposure duration.

D. When specific information on the physical and biokinetic properties of the radionuclides taken into the body or the behavior of the material in an individual is known, the following may occur:
    1. This information may be used to calculate the committed effective dose equivalent, and, if used, shall be documented in the individual's record; and
    2. With prior approval from the RCP, adjust the DAC or ALI values to reflect the physical and chemical characteristics of the airborne radioactive material (e.g. particle size distribution and other applicable correction factors); and
    3. Separately assess the fractional contribution of Class D, W, or Y compounds of a given radionuclide to the committed effective dose equivalent.
E. When the specific information on the physical, chemical, or biokinetic properties of the radionuclides taken into the body or the behavior of the material is unknown, the following may occur:
    1. The most restrictive ALI or DAC may be used to calculate the committed effective dose equivalent, and, if used shall be documented in the dose calculation record; and
    2. The ALI of the initial radiolabeled compound may be used to calculate the committed effective dose equivalent, and, if used shall be documented in the dose calculation record; or
    3. The most restrictive ALI or DAC in a mixture of chemical compounds may be used to calculate the committed effective dose equivalent, and, if used, shall be documented in the dose calculation record.
F. According to the license conditions, individuals involved in operations, at any one time, more than 100 mCi of tritium in a non-contained form, other than metallic form, shall have bioassays performed within one week following single operation and at weekly intervals for continuing operations. Contact RSP at 713-500-8100 to arrange a bioassay.
G. The Authorized User should ensure that personnel performing radioactive material protocols obtain internal dose assessments when warranted.
H. The RSP will perform an internal dose assessment to radiation workers upon written request by the individual.

7.2.1 Criteria Requiring Internal Dose Assessment

The annual activity limits, Table 2, requiring internal dose assessment were derived from the CRC Handbook for Radiation Protection Programs (Brodsky 1992).

Table 2: Annual activity limits requiring internal dose assessment (adapted from Brodsky 1992).

Radionuclide	Type of Confinement	Annual Activity Level (Volatile)	Annual Activity Level (Non-Volatile)
^{3}H	Chemical Fume Hood	400 Ci	4000 Ci
	Open lab bench	40 Ci	400 Ci
	Special operation (unknown ventilation)	4 Ci	40 Ci
^{125}I or ^{131}I	Chemical Fume Hood	200 mCi	2000 mCi
	Open lab bench	20 mCi	200 mCi
	Special operation (unknown ventilation)	2 mCi	2 mCi
Dispersible Alpha Source	Chemical Fume Hood	200 mCi	2000 mCi
	Open lab bench	20 mCi	200 mCi
	Special operation (unknown ventilation)	2 mCi	20 mCi
Dispersible Beta/Gamma Source	Chemical Fume Hood	100 Ci	100 Ci
	Open lab bench	10 Ci	10 Ci
	Special operation (unknown ventilation)	10 Ci	10 Ci

Additionally, the quarterly activity limits, Table 3, for I-125 and I-131 recommending internal dose assessments were derived from the Texas Department of State Health Services Radiation Safety Licensing Branch Regulatory Guide 5.9 Bioassay Requirements for I-125 and I-131. Bioassay measurement frequencies will be determined on a case by case basis. When work with radioactive iodine at levels indicated in Table 2 is on an infrequent basis (less frequently than every two (2) weeks), bioassay may be performed within ten (10) days of the end of the work period during which radioactive iodine was handled (but not sooner than six (6) hours unless emergency actions to obtain an early prognosis and thyroid blocking treatment are appropriate). In those laboratories working only with I-125 in radioimmunoassay (RIA) kits, the quantities of I-125 are very small and in less volatile forms; bioassay requirements in cases where RIA kits are being used, therefore, may be judged from the right hand column.

Table 3: Quarterly activity limits recommending internal dose assessment (from Texas Regulatory Guide 5.9).

Radionuclide	Type of Confinement	Quarterly Activity Level (Volatile)	Quarterly Activity Level (Non-Volatile)
^{125}I or ^{131}I	Process carried out within glove boxes, ordinarily closed, but with possible release of from process and occasional exposure to contaminated box and box leakage.	200 mCi	2000 mCi
	Process with possible escape of iodine carried out within a fume hood of adequate design, face velocity, and performance reliability.	10 mCi	100 mCi
	Process in open room or bench, with possible escape of iodine from process vessels.	1 mCi	10 mCi

7.3 Summation of External and Internal Dose

A. The RSP shall demonstrate compliance with the applicable dose limits (e.g. Total Effective Dose Equivalent or Total Organ Dose Equivalent) by summing the external and internal doses, if required. The dose equivalents for the lens of the eye, the skin, and the extremities are not included in the summation.
B. If the RSP is required to monitor only in accordance with *25 TAC §289.202*, then summation is not required to demonstrate compliance.
C. If the only intake of radionuclides is through inhalation, the total effective dose equivalent is not exceeded if the sum of the deep dose equivalent divided by the total effective dose equivalent limit, and one of the following, does not exceed unity:
    1. the sum of the fractions of the inhalation ALI for each radionuclide: or
    2. the total number of derived air concentration-hours (DAC-hours) for all radionuclides divided by 2000; or
    3. the sum of the calculated committed effective dose equivalents to all significantly irradiated organs or tissues calculated from bioassay data using appropriate biological models and expressed as a fraction of the annual limit.
D. If the occupationally exposed individual receives an intake of radionuclides by oral ingestion greater than 10% of the applicable oral ALI (*25 TAC §289.202 (ggg)(2)*), the RSP shall account for this intake in the committed effective dose equivalent, as necessary.
E. The RSP shall evaluate, to the extent practical, and account for intakes through skin absorption or wound injection. The RSP shall account for this intake in the committed effective dose equivalent, as necessary.

8. Surveys, Postings, and Instrumentation

8.1 Laboratory Surveys by Authorized Users

Good housekeeping practices within the laboratory are fundamental to maintaining a safe environment. To ensure that radiation exposure does not result in a hazard to others, each Authorized User should perform appropriate surveys for external radiation and contamination

following each procedure when the radioactive material is used. Radiation surveys serve to identify and quantify radiological hazards and document regulatory compliance. Radiation surveys protect employees, members of the general public, and the environment from the harmful effects of radiation.

In general, "surveys" may be divided into two general categories.

1. **Area Radiation Surveys** - quantifies the ambient radiation fields in and around the laboratory. The purpose is to ensure that radiation field levels are in compliance.
2. **Contamination Surveys** - quantifies removable and fixed radioactive material contamination in and around the laboratory. The purpose is to prevent or identify personnel contamination and monitor the efficacy of existing radiation safety measures.

8.2 Laboratory Area Radiation Surveys

Laboratories using gamma-emitting radionuclides (e.g. ^{51}Cr, ^{86}Rb, ^{22}Na, or ^{137}Cs) should perform area radiation monitoring with an appropriate portable survey instrument. Area radiation surveys are not appropriate for short-lived (e.g. half-life less than one day) positron-emitting radionuclides. Area radiation surveys are not appropriate for laboratories using only beta-emitting radionuclides since the emissions are not efficiently detected by commonly available ambient field portable survey instruments. Laboratories exclusively using beta-emitters must rely upon contamination surveys analyzed in an appropriate instrument (e.g. liquid scintillation counter) to ensure the absence of radioactivity.

A. Work areas and equipment monitoring should be carried out after each procedure by means of a portable radiation survey meter. The laboratory should also be surveyed routinely. All radioactive material work areas, bench and table tops, sinks, drains, traps, floors, *etc.*, are to be included in this survey.
B. Authorized Users must have access to a survey meter available that is appropriate for the kind and activities of the radionuclides used.
C. If contamination of the body or clothing is suspected, monitoring of the suspected parts and decontamination, if necessary, shall be conducted immediately. Contact the RSP at 713-500-8100 for assistance.

8.3 Laboratory Contamination Surveys

Contamination surveys are readily accomplished through "wipe tests". Wipe tests are a method of determining the presence of removable contamination and must be performed in addition to any area radiation surveys required. Authorized Users should require performance of surveys of the work area after each procedure involving unsealed sources of radioactivity.

Authorized Users are required by the RSC to document laboratory wipe tests at least once a month in each of their laboratories where radioactive material is used. Monthly wipe test records are subject to inspection at any time and are part of the routine safety audit program performed by the Radiation Safety Program. The monthly wipe test requirement provides a modicum of assurance that removable contamination is not present in the workplace. In situations involving larger quantities of Radioactive Materials, Authorized Users are encouraged to evaluate their wipe test frequencies based on the following criteria, to further enhance lab safety. It is not necessary to retain these additional surveys.

A. Daily or after each operation in areas where 100 mCi per protocol or more of dispersible radioactive materials are used.
B. Weekly in areas where 50 mCi to 100 mCi per protocol of dispersible radioactive

materials are used.

C. Monthly in areas where fewer than 50 mCi per protocol of dispersible radioactive materials are used.

Documented meter surveys using an appropriate portable survey instrument may be substituted for wipe tests for short-lived radionuclides (e.g. half-life less than one day).

8.3.1 Laboratory Contamination Survey Procedure

Contamination surveys (e.g. wipe tests) should be performed as follows:

A. A cotton swab, filter discs, or other absorbent media may be used for wiping each location. Protective gloves should be worn while performing contamination surveys when using media other than cotton swabs. Vigorously wipe the location-of-interest with the swab or filter paper disc. Any radioactive material loosely deposited on the surface of the location should be transferred to the wiping medium.

B. Wipe tests should be taken at strategic locations throughout the laboratory, each covering an area (where possible) of approximately 100 cm^2. Typically, eight (8) to fifteen (15) wipes are taken. Larger laboratories may require more wipes. Areas to consider for testing include the following:
   1. work benches reserved for radionuclide use
   2. fume hoods (especially the accessible front area and handle)
   3. sinks and adjacent areas
   4. radioactive material storage containers
   5. refrigerator or freezer handles
   6. light switches, telephones and door handles
   7. floor areas surrounding radioactive material use
   8. laboratory equipment (centrifuge, balances, racks, or incubators)
   9. locations where contamination is likely

C. For wipe tests that must be documented (e.g. monthly), the wipe location must be documented and the wipe analyzed on equipment capable of measuring the levels and types of radiation anticipated in the lab (e.g. liquid scintillation counter and/or gamma counter).

D. **Decontamination Action Level**: While any excess activity should be removed when discovered, areas with wipe test results of 1,000 dpm/100 cm^2 or greater of removable contamination for beta- and gamma-emitting radionuclides must be decontaminated until further wipe tests show results below this threshold. In general, radioactive material contamination should warrant investigation into contributing sources.

8.3.2 Laboratory Contamination Survey Records

A. A copy of the monthly wipe test results should be retained in the laboratory. For convenience, Authorized Users are provided binders in which to retain all required documents.

B. Laboratory wipe test results should be retained in the laboratory for review during routine safety audits and review during inspections performed by the Radiation Control Program. To eliminate significant accumulation of paperwork, the Authorized User may remove records from prior to the last state RCP inspection (in general, every 2-3 years which corresponds with RCP inspections). The RSP should be contacted prior to the disposal of records to ensure compliance.

8.3.3 Documentation of Laboratory Contamination Surveys

Schematic diagrams of work areas are used to identify the locations where wipe test

samples are taken. Space for such diagrams is provided on the Authorized User Laboratory Wipe Test Report. Photocopies of each diagram are advantageous for future use. Use the copies to document wipe and counting results.

A. Although the most important feature of any wipe test is the results of the sample analysis (e.g. removable activity detected), such data is not useful if other tracking information is not available. Therefore, it is recommended that each wipe test record contain the following information:
   1. Building and room number of laboratory wipe tested.
   2. Month that the wipe test is being performed.
   3. Name of the person performing the wipe tests.
   4. Date of survey.
   5. Authorized User's name.
   6. List of radionuclides used in the laboratory.
   7. Model, type, and serial number of counting equipment used.
   8. Radioisotope standards used to calculate efficiency.
   9. Type of counting device (e.g. gamma or LSC).
   10. Energy range where samples are counted.
   11. Background count rate (cpm).
   12. Efficiency of counter at region counted. May be omitted if equipment can automatically convert to dpm.
   13. Identification of the location of each wipe taken.
   14. Wipe test results in dpm or printout from counter. The dpm value may be calculated using the following formula:

$$\text{DPM} = \frac{\left[\text{CPM} - \text{Background}\right]}{\text{Efficiency}}$$

   15. Commentary regarding actions taken in case of contamination (e.g. decontamination and re-wipe documentation).

8.4 Radioactive Waste Alcove Contamination Surveys

Contamination surveys of radioactive waste alcoves are readily accomplished through "wipe tests". Wipe tests are a method of determining the presence of removable contamination. Radioactive waste alcoves are designated storages areas throughout campus for the temporary storage of solid radioactive waste and liquid scintillation vials until processed by the Environmental Protection Program. The EPP will document radioactive waste alcove contamination surveys at least quarterly in each alcove where radioactive waste is stored. The quarterly wipe test requirement for the radioactive waste alcoves provides a modicum of assurance that removable contamination is not present in the workplace.

8.4.1 Radioactive Waste Alcove Contamination Survey Procedure

Contamination surveys (e.g. wipe tests) should be performed as follows:

A. A cotton swab, filter discs, or other absorbent media may be used for wiping each location. Protective gloves should be worn while performing contamination surveys when using media other than cotton swabs. Vigorously wipe the location-of-interest with the swab or filter paper disc. Any radioactive material loosely deposited on the surface of the location should be transferred to the wiping medium.
B. Wipe tests should be taken at strategic locations throughout the alcove, each covering an area (where possible) of approximately 100 cm^2. Areas to consider for testing

include the following:

1. radioactive waste storage containers
2. light switches, and door handles
3. floor areas including doorway surrounding radioactive waste storage
4. locations where contamination is likely

C. **Decontamination Action Level**: While any excess activity should be removed when discovered, areas with wipe test results of 1,000 dpm/100 cm^2 or greater of removable contamination for beta- and gamma-emitting radionuclides must be decontaminated until further wipe tests show results below this threshold. In general, radioactive material contamination should warrant investigation into contributing sources.

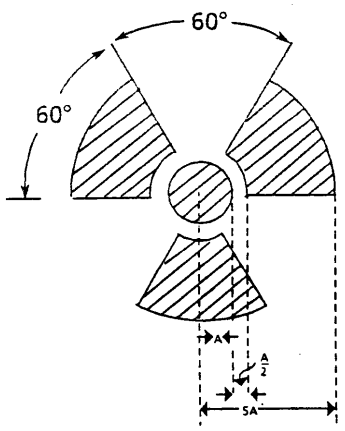
8.5 Radiation Notices, Signs, and Labels

The following information must be available to all employees who receive, possess, use, or transfer sources of radiation at UTHealth. The following documents must be posted or referenced in conspicuous places in sufficient work areas:

A. 25 *Texas Administrative Code §289* Radiation Control Program Rules available online: https://www.dshs.texas.gov/radiation/laws-rules.aspx.
B. The radioactive material license, certificates of registration, conditions or documents incorporated into the license, and supplemental amendments;
C. The operating procedures applicable to work under the license or registration;
D. Any outstanding notice of violation, order, or response stemming from regulatory inspection activities; and
E. The Agency Form 203-1, "Notice to Employees" which is available under §289.203 For Dentists & Veterinarian's see the Applicable Notice to Employees.

8.5.1 Posting Requirements

The following symbol shall be used for describing radioactive materials. The symbol shall use the colors magenta, purple, or black on a yellow background.



8.5.2 Types of Postings

The following postings must be appropriate for the indicated hazard and conspicuous.

A. **Caution Radiation Area** - any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5 mrem in 1 hour at 30 centimeters from the source of radiation or any surface the radiation penetrates.

B. **Caution High Radiation Area** - any area, accessible to individuals, in which levels could result in an individual receiving a dose equivalent in excess of 100 mrem in 1 hour at 30 centimeters from the source of radiation or from any surface that the radiation penetrates.
C. **Grave Danger Very High Radiation Area** - any area, accessible to individuals, in which levels could result in an individual receiving an absorbed dose in excess of 500 rad in one hour at 1 meter from a source of radiation or from any surface that the radiation penetrates.
D. **Caution Airborne Radioactivity Area** - any room or area in which airborne radioactive materials exist in concentrations in excess of levels specified in the rules.
E. **Caution Radioactive Material** - should be posted at all doors or entrances to rooms or areas in which licensed radioactive materials are used or stored (excluding natural uranium, thorium, ^{63}Ni, and other exempt sources).
F. Additional postings shall be dictated by the level of hazard, degree of control in the area, and available facilities.

8.5.3 Labeling Containers and Radiation-Producing Machines

Prudent laboratory practice warrants labeling of all containers (e.g. flasks, beakers, jars, tubes) with some type of conspicuous label identifying the contents. This may also be applied to radioactive materials in the laboratory environment.

A. In order to prevent contamination of employees, general public, and future experiments, the RSC recommends labeling containers regardless of the contained activity.
B. The Authorized User should ensure that unattended containers with activities exceeding the following limits are labeled with "Caution Radioactive Material" and the radiation symbol.

Table 4: Quantities of selected licensed materials requiring labeling.

Radionuclide	Activity Requiring Labeling (μCi)
^{3}H	1000
^{14}C	1000
^{22}Na	10
^{32}P	10
^{33}P	100
^{35}S	100
^{125}I	1
^{45}Ca	100
^{86}Rb	100
^{51}Cr	1000

C. The Authorized User should ensure that each container of licensed material is labeled with sufficient information to permit employees handling or using the container to minimize radiation exposures.
D. The Authorized User should ensure that radioactive postings or labels are defaced, removed, or obscured prior to disposal of empty uncontaminated containers for unrestricted use.

E. The Authorized User should ensure that each radiation-producing machine is labeled in a conspicuous manner advising individuals that radiation is produced upon energizing.

8.5.4 Exemptions and Exceptions to Posting

A. Containers attended by individuals who take precautions necessary to minimize or prevent radiation exposure are not required to be labeled.
B. Containers which are in transport and packaged and labeled in accordance with U.S. Department of Transportation regulations are not required to be labeled.
C. Containers which are accessible only to individuals authorized to handle or use them (e.g. restricted by appropriate security measures) are not required to be labeled. Documentation must still be available in order to minimize or avoid radiation exposures.
D. Precision-manufactured equipment (e.g. centrifuge rotors) which may be damaged or unusable through posting are not required to be labeled. In this case, the contaminated equipment may be labeled on a secondary surface in order to convey the potential hazard.
E. Installed or process equipment (e.g. pipes or tanks) are not required to be labeled or posted.
F. A room or area is not required to be posted with a caution sign due solely to the presence of a sealed source. The radiation level must exceed 0.005 rem per hour at 30 centimeters from the sealed source container or shielding.

**For appropriate laboratory door postings or posting questions, please contact the Radiation safety Program

8.6 Instrumentation

Radiation detectors at UTHealth may be categorized as follows:

1. **Quantitative** - These radiation survey instruments are operated in a manner to produce absolute quantities (e.g. effluent monitoring or package receipt surveys). The response of these instruments determines regulatory compliance with a dose, contamination, shipping, or release limit.
2. **Qualitative** - These radiation detectors are operated in a manner to merely determine the presence or absence of radioactive materials. These instruments are not utilized in determining regulatory compliance with applicable dose limits.

8.6.1 Radiation Detector Calibration Requirements

A. Radiation detectors used for quantitative measurements shall be calibrated at intervals not to exceed 12 months.
B. Radiation detectors used for qualitative measurements should be calibrated or response-checked at intervals not to exceed 12 months.
C. Radiation detectors may be calibrated by the RSP, the instrument manufacturer, or a licensed or registered calibration service provider.
D. Quantitative radiation detectors which are serviced or repaired shall be recalibrated following the repair. Recalibration is not essential for minor changes which will not affect the instrument response characteristics (e.g. battery replacement).
E. Radiation detectors used for quantitative measurements shall be calibrated for the type of radiation encountered and the energies appropriate for use at an accuracy within ±20% of a reference value.

8.6.2 Requirements for Possessing a Detector

A. Each Authorized User should possess or have access to a radiation detector which is appropriate for the potential hazard in their laboratory.
B. Authorized Users possessing high-energy beta- or gamma-emitting radionuclides should possess or have access to a portable radiation detector.
C. Users authorized for less than 0.5 mCi of ^{3}H, ^{14}C, ^{35}S, ^{63}Ni, or ^{33}P (i.e. any low-energy beta-emitting radionuclide) are not required to possess a portable radiation detector. The Authorized User should have access to a detector sufficient for quantifying the degree of laboratory contamination.
D. Users authorized for only ^{63}Ni in gas chromatographs or natural uranium or thorium compounds of 3 kilograms (6.6 pounds) or fewer are not required to possess a radiation detector.
E. Authorized Users possessing only sealed sources presenting a minimal radiation exposure hazard are not required to possess a radiation detector.

8.6.3 Guidelines for Using Radiation Detectors

A. Radiation detectors shall be used in accordance with manufacturer specifications or procedures. Failure to adequately follow these guidelines may result in erroneous readings.
B. Before using a radiation detector in the field, the detector should be checked for operability and the detector response should be evaluated.
C. Thin or open window probes should be operated in a manner which prevents contamination of the detector face.
D. High radiation fields may not be accurately detected with GM probes due to electronic effects. Use caution when evaluating radiation fields with a GM probe. Contact the RSP for additional information.
E. Low-energy beta-emitting radionuclides are not efficiently detected using a portable radiation detector. In general, this class of radionuclides should be evaluated using a liquid scintillation counter.
F. Low-energy x-ray sources (e.g. ^{125}I) are most efficiently detected using a thin-window NaI scintillation probe. The RSP should be contacted for further details.

9. Laboratory Safety Audits by EH&S

In order to assist and support the safe use of radioactive material at UTHealth Houston, the Environmental Health & Safety staff conducts routine audits of Authorized User activities. These radiation audits may be classified as follows:

A. **Authorization Review** - This audit evaluates the Authorized User contact information, laboratory locations, radioactive material inventory, laboratory personnel and training, portable radiation survey instrument availability and calibration, and radioactive waste disposal issues. This audit is intended to evaluate the conditions and parameters of the radioactive material authorization set by the RSC. The frequency of the review is twice per calendar year and may occur in tandem with the Laboratory Safety Evaluation.
B. **Laboratory Safety Evaluation** - This on-site audit is performed by the EH&S staff at the Authorized User's facility. This audit should evaluate emergency response information, postings and labeling, facilities, records, RAM handling and use, RAM storage and security, radioactive waste disposal, personnel dosimetry, laboratory

radiation levels, and other safety issues as needed. The frequency of the audit is twice per calendar year.

The Authorized User is ultimately responsible for compliance with safety and health issues in facilities under their jurisdiction. The intent of safety audits and subsequent items of non-compliance is to notify the Authorized User of potential safety issues in the research environment.

The frequency of on-site audits may be accelerated due to enforcement actions recommended by the RSC, significant increases in radioactive material use, a request by the Authorized User, or other safety conditions warranting additional oversight.

9.1 Inspection Criteria

The on-site radiation safety audits performed by the EH&S staff evaluate potential radiological hazards, determine the concentrations and quantities of radioactive material, and ensure compliance with applicable regulatory issues in the research environment. The on-site audit is an essential tool for evaluating safety in the laboratory. To this end, the RSC or RSO may accelerate the on-site audit schedule if prudent judgment obligates such action.

The following items are incorporated in this document to outline the breadth of the routine inspection criteria. Necessary parameters will be added or deleted without notification. In addition, not all items will be evaluated for each research facility. The degree of radiological hazard will guide inspection criteria.

A. Emergency response information;
B. Appropriate postings and labeling;
C. Facilities Review;
D. General Safety Review (e.g. absence of food or drink in lab, presence of PPE)
E. Radioactive Material Inventory Review;
F. Radioactive Material Use and Handling Review;
G. Radioactive Material Security or Storage Review;
H. Radioactive Waste Disposal Review;
I. Radiation Dosimetry Review;
J. Laboratory Radiation Contamination Survey; and
K. Other conditions, as necessary.

9.2 Results of Inspections

Audits conducted by the EH&S staff will be used to determine the Authorized User's compliance with Texas Department of State Health Services, Radiation Control Program regulations and conditions outlined in this document. The audit record will be retained by the RSP. Permanent records of laboratory inspections will be available for inspection at any time by the Authorized Users, the RSO, the ARSO, members of the RSC, or representatives of the Texas Department of State Health Services, Radiation Control Program.

Laboratory safety audit findings will be directed to the Authorized User. Items of non-compliance will generally require prompt rectification by the responsible parties. A summary of on-site audit activities conducted by the RSP will be presented to the RSC.

9.2.1 On-site Audits with No Observed Deficiencies

Audits conducted by the RSP which result in no items of non-compliance will be deemed successful. No response or clarifying documentation will be required.

9.2.2 On-site Audits with Observed Deficiencies

Items of non-compliance observed during audit activities will be conditionally handled accounting for the degree of hazard present in the facility, severity to employee health

and safety, technological feasibility, or other mitigating circumstances. Audits conducted by the EH&S staff which result in items of non-compliance may require the following:

A. Verbal response by laboratory personnel;
B. Follow-up audit by the EH&S staff;
C. Written response by laboratory personnel;
D. Written response and supporting documentation by the Authorized User;
E. Consultation with the RSO and/or ARSO;
F. Non-compliance hearing before the RSC; or
G. Immediate intervention by the RSO and/or ARSO when imminent concern for safety and health exist.

9.2.3 Findings of Repeated Observed Deficiencies

Items of non-compliance which consistently appear in Authorized User facilities warrant additional consideration from the EH&S staff. Repeated items of non-compliance will be dealt with according to the degree of hazard presented to the facility, the threat to employee health and safety, and any other conditions of concern.

9.3 Procedure for Addition of a Radioactive Material Laboratory

The prospective Authorized User is not required to provide labeled drawings of facilities with the original applications as each facility is evaluated by the RSP as part of the application review process.

A. The new applicant for radioactive material use in the research environment should specify facility information with the RSC on the initial Radioactive Material Use Application (RS-01A and RS-01B). An Authorized User may conditionally add laboratories by filing a Radioactive Material Use Amendment (RS-11) or a completed Authorization Review, or written notification with the RSP.
B. The Radiation Safety Program should review applicable facility issues during an "opening" laboratory evaluation including but not limited to:
    1. Emergency response information;
    2. Appropriate posting and labeling;
    3. Facility review and evaluation;
    4. Shielding review and evaluation;
    5. RAM use and handling review;
    6. RAM storage and security;
    7. Radioactive waste disposal review;
    8. Laboratory radiation contamination survey; and
    9. Other conditions, as necessary.
C. Upon successful completion of an opening survey, the new laboratory will be added to the Authorized User's list of approved radioactive material use areas.
D. Notifications of amendments to authorization parameters (excluding personnel changes, room and contact information) are provided to the RSC for review and approval.

9.4 Procedure for Decommissioning a Radioactive Material Laboratory

A radioactive material laboratory may be decommissioned through the request of the Authorized User, the Department Chair or Dean, the RSO, the RSP or the RSC.

A. The RSP shall review applicable facility issues during a decommissioning laboratory evaluation including but not limited to:
    1. Emergency response information;

2. Appropriate posting and labeling;
3. Facility review and evaluation;
4. Radioactive source and waste review;
5. Laboratory radiation contamination survey; and
6. Other conditions, as necessary.

B. Prior to vacating any facility or releasing areas or equipment for unrestricted use, the RSP or the Authorized User shall ensure that radioactive contamination has been removed to levels as low as reasonably achievable. In no case shall the licensee vacate a facility or release areas or equipment for unrestricted use until surface contamination levels are below the activity limits specified in *25 TAC §289.202 (ccc)*.

C. In the event of long-lived (e.g. half-life exceeding 300 days) non-removable radioactive material contamination existing on equipment or facilities which will continue to be used in the research environment which does not pose a significant exposure potential, the contamination shall be labeled with appropriate identifying and cautionary information and retained in the laboratory. The location of the non-removable radioactive material contamination shall be maintained for ultimate disposal in conjunction with the decommissioning plan per *25 TAC §289.252*.

D. Following a successful decommissioning audit by the RSP, the laboratory will be removed from the Authorized User's radioactive material jurisdiction and responsibility.

10. Human Use of Radiation Sources

The administration of radioactivity in humans is governed by the Food and Drug Administration, the Nuclear Regulatory Commission and the Texas Department of State Health Services. Any administrations of radioactive substances to humans must be performed by or under the authorization of physicians who are licensed to perform the procedure. Specific guidance regarding training and licensing requirements for physicians can be found in the Texas Department of State Health Services, Radiation Control Program, *25 TAC §289.256 (jj)*, Acceptable Training and Experience for Medical Uses of Radioactive Material. The use of radioactive material in humans must be done in accordance with the broad license L02774 for the sites listed on the permit. Additional information regarding the preparation, dispensing, and delivery of radiopharmaceuticals is available from the Radiation Safety Program of UTHealth Houston.

10.1 Requirements for Human use of Radioactive Material

10.1.1 General Requirements

Authorized Users requesting human use of radioactive material must fulfill the general requirements outlined in *25 TAC §289.256 (jj)* which includes:

A. All personnel directing, preparing, or handling the radioactive material must be qualified by reason of training or experience to use the radionuclide in question;

B. The proposed facilities, equipment, and procedures are adequate to minimize danger to public health and the environment; and

C. The protocol is not adverse to the health and safety of the public.

D. Specific approval must be granted for the protocol by the appropriate committee within UTHealth Houston before initiating the protocol.

E. Follow the report requirements for medical event (formerly known as clinical misadministrations) found under 25TAC§289.256(c)(14, definition of medical event,

and §289.256(uuu), "Report and Notification of a Medical Event." For additional guidance, contact the RSP. Examples include: The total dose delivered differs from the prescribed by 20% or more. An administration to the wrong individual.

10.1.2 Special Requirements, Including Pregnancy Screening

Additional requirements are imposed to provide the best care to the patient, minimize the radiation exposure to the clinical staff, and ensure compliance with all applicable regulations. In addition to the general requirements set forth in *25 TAC §289.256 (jj)*, special requirements are established which include:

A. The Authorized User must possess adequate facilities for the clinical care of patients;
B. The physician designated on the application has completed the training and experience requirements in *25 TAC §289.256 (jj)*, as applicable; and
C. Maximum patient care may be administered while still maintaining appropriate radiation safety standards.
D. Female patients, ages 12 – 55, shall be screened for pregnancy prior to performing diagnostic imaging studies such as PET or PET/CT.
    a. All female patients within childbearing age (12-55 yrs) will be asked in written form or verbally if they are or could be pregnant prior to any diagnostic nuclear medicine procedure.
    b. If the patient is unable to confirm the absence of pregnancy (e.g. mentally impaired or unusually long menstruation period), a urine pregnancy test will be performed prior to any diagnostic nuclear medicine procedure.
    c. If the patient is pregnant, the radiologist and the attending physician will be consulted before proceeding with the diagnostic nuclear medicine procedure.
    d. If the attending physician and the radiologist agree that the diagnostic information received outweighs the risks, then the test or treatment will be performed with written consent for treatment signed by the patient.
    e. The following is provided as guidance to the clinical staff:

For use of radiation on UTHealth Houston's permits located within Memorial Hermann Hospital, also consult ***Memorial Hermann Hospital's Corporate Policy & Procedures Manual***, Policy Title: *Nuclear Medicine – Pregnant Patients – Non-Therapeutic Exams*, Category: Outpatient Imaging, OPI-01552.

- **Diagnostic PET and PET/CT studies at UTHealth Houston permitted locations**
    - The vast majority of routine diagnostic studies deliver less than 20 mSv (20 mGy) or 2,000 mrem to the uterus, and single-phase acquisition computed tomography (CT) of the abdomen including pelvis usually delivers less than 35 mSv (35 mGy) or 3,500 mrem (McCollough, 2007; Angel, 2010; Koller, 2003).
    - Typical diagnostic PET/CT studies at the Weatherhead PET Imaging Center are less than 40 mGy or 4,000 mrem. This varies depending on the size of the patient and the amount of radioactivity (e.g. F-18 FDG) administered.
- **Screening for Pregnancy of Patients to Maintain Doses As Low As Reasonably Achievable**
    - The purpose of the screening of patients for pregnancy is to avoid unintended doses to the fetus. The attending physician and the radiologist may decide that the diagnostic information received outweighs the risks, then the test or treatment will be performed with written consent for treatment signed by the patient.
- **Questioning the Patient**
    - Prior to an examination, the patient usually can supply adequate information to assess the possibility of pregnancy. All patients of menstrual age (typically ages 12 through 55 years) should be questioned about pregnancy status using a standardized form and/or through direct questioning by the technologist. A standardized form has the advantage of ensuring uniformity in the questioning process, and it can serve as documentation of pregnancy status. **A template form has been provided.**

- Minors (under age 18) - The minor is also particularly vulnerable to social and parental pressures that can potentially result in the patient providing misinformation about her reproductive status. One approach to rectify this situation is for the technologist to ask the parent or guardian for permission to prepare the patient in the examination room privately prior to the examination. In the private setting the technologist can either ask the patient the standard questions or can ask the patient to fill out the standard form about menstrual history and the potential for pregnancy. If a private preparation is refused, then a backup screening policy can be put in place. The policy may require that a radiologist interview the patient prior to the examination, for example. As an alternative to the above method, the institutional policy might indicate that all minors who begun menstruating and are have not already known to be pregnant are to undergo a pregnancy test prior to any diagnostic procedure. An Ob/Gyn physician may be consulted for recommendations regarding minors and determining potential pregnancy.
- If the patient is mentally impaired or incapacitated such that she can not reasonably confirm the absence of pregnancy, then a urine pregnancy test or another pregnancy test will be conducted prior to administration of the diagnostic radiation test.

➢ **Pregnancy Tests**

- If the patient does not pass standard verbal or written screening queries about menstrual history or potential for pregnancy, the radiologist and attended physician should be notified and the date and results of the pregnancy test should be included in the notification.
- The standard urine pregnancy test in most cases satisfies the test for pregnancy.
- For some procedures that are expected to deliver relatively high doses to a conceptus, a pregnancy test should be obtained within 72 hours prior to commencement of the procedure unless medical exigencies prevent it. These procedures might include any examination that involves unpredictable duration of fluoroscopy of the pelvis and some abdominal/pelvic CT protocols. Interventional procedures, diagnostic angiography of the pelvis, hysterosalpingography, or standard-dose dual-phase CT protocols of the pelvis are examples.

➢ **Deciding to Proceed with the Diagnostic Radiation Imaging**

- If a patient can reliably answer that 1) she cannot be pregnant and that 2) she had a recent complete menstrual period, then it is reasonable to proceed with a medically indicated diagnostic PET or PET/CT test of the abdomen or pelvis. The last complete menstrual period should have occurred within the previous 4 weeks. During this interval diagnostic radiation represents no substantive risk to a conceptus.
- The following table of Suspected In-Utero Induced Deterministic Radiation Effects can be used as guidelines in the management of pregnant or potentially pregnant patients. This table is an excerpt from ACR Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation available online at:
  - http://www.acr.org/~/media/ACR/Documents/PGTS/guidelines/Pregnant_Patients.pdf

Table 1: Summary of Suspected In-Utero Induced Deterministic Radiation Effects*

Menstrual or Gestational age	Conception age	<50 mGy (<5 rad)	50-100 mGy (5 - 10 rad)	>100 mGy (>10 rad)
0 - 2 weeks (0 - 14 days)	Prior to conception	None	None	None
3rd and 4th weeks (15-28 days)	1st-2nd weeks (1-14 days)	None	Probably none	Possible spontaneous abortion.
5th - 10th weeks (29 - 70 days)	3rd-8th weeks (15-56 days)	None	Potential effects are scientifically uncertain and probably too subtle to be clinically detectable.	Possible malformations increasing in likelihood as dose increases.
11th - 17th weeks (71- 119 days)	9th-15th weeks (57-105 days)	None	Potential effects are scientifically uncertain and probably too subtle to be clinically detectable.	Increased risk of deficits in IQ or mental retardation that increase in frequency and severity with increasing dose.
18th - 27th weeks (120 - 189 days)	16th - 25th weeks (106 - 175 days)	None	None	IQ deficits not detectable at diagnostic doses.
>27 weeks (>189 days)	>25 weeks (>175 days)	None	None	None applicable to diagnostic medicine.

*Stochastic risks are suspected but data are not consistent [5]. For exposure to a newborn child, the lifetime risk of developing cancer is estimated on an absolute scale to be 0.4% per 10 mGy (1 rad) dose to the baby. This likely also reflects the potential risk in-utero for the second and third trimesters and part of the first trimester, but the uncertainties in this estimate are considerable.

- Other Radiological Safety Resources specific to radiation imaging are available at:
  - **http://www.acr.org/safety**

➢ **References**

- American College of Radiology (ACR), Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation, 2008, available online at:
  - **http://www.acr.org/~/media/ACR/Documents/PGTS/guidelines/Pregnant_Patients.pdf**
- McCollough CH, Schueler BA, Atwell TD, et al. Radiation exposure and pregnancy: when should we be concerned? *Radiographics* 2007;27:909-917; discussion 917-908.
- Angel E, Wellnitz C, Goodsitt MM, et al. Estimating radiation dose from multidetector CT using monte carlo simulations: Fetal dose for a range of gestational ages and patient sizes. *Radiology* Pending Revisions.
- Koller CJ, Eatough JP, Bettridge A. Variations in radiation dose between the same model of multislice CT scanner at different hospitals. *Br J Radiol* 2003;76:798-802.

Instructions for the Form

1.) Before any diagnostic imaging but foremost if the patient is scheduled abdominal CT, fluoroscopy, or Nuclear Medicine PET procedures the imaging technologist shall screen female patients between age 10 and 55 for possible pregnancy.

2.) The **Pre-examination Pregnancy Determination Form** or an equivalent form should be utilized to document the pregnancy screening. Verbal questioning can substitute for the form if the questioning is provided in a uniform fashion for all female patients as described in 1).

3.) If the patient is hesitant or unsure of whether she is pregnant, a pregnancy test shall be done prior to diagnostic imaging. If the patient is unable to confirm the absence of pregnancy (e.g. mentally impaired or unusually long menstruation period), a urine pregnancy test will be performed prior to any diagnostic nuclear medicine procedure. If the patient cannot communicate a pregnancy, the pregnancy test shall be conducted.

4.) If the pregnancy test is warranted from the screening and refused by the patient, the attending radiologist shall decide whether to go on with the diagnostic study.

5.) If the patient is pregnant, the radiologist and the attending physician will be consulted before proceeding with the diagnostic nuclear medicine procedure.

6.) If the attending physician and the radiologist agree that the diagnostic information received outweighs the risks, then the test or treatment will be performed with written consent for treatment signed by the patient. If the patient hesitant or not sure about her pregnancy status a pregnancy test has to be performed.

7.) Ideally the Pregnancy Waiver Form includes a consent section for the patient to sign which states that the patient understands the procedures and possible ramification of the study should she knowingly provide false information regarding her pregnancy.

PRE-EXAMINATION PREGNANCY DETERMINATION FORM

PATIENT: _____ **MRN:** _____

DATE: _____ **TIME:** _____

TECHNOLOGIST: _____ **RADIOLOGIST or PHYSICIAN:** _____

We would like to take a few moments to understand the importance of assessing whether or not you might be pregnant before you have your radiologic examination.

It is unlikely that your radiological examination would result in any adverse effect on your unborn child, should you be pregnant. But the risk from radiation exposure is not zero. There is evidence that radiation exposure to an unborn child can cause a slight increase in the risk of the child developing cancer at a later time in life. At the radiation levels delivered in our tests, there is no evidence for an increase in risks for malformation or other serious birth defects. While the increased cancer risk is slight, it is important that any such risk be avoided when possible. Please take a few moments to answer the questions below in order to assist us in determining whether you are or could be pregnant.

1. What was the first day of your last complete menstrual period?_____

2. To the best of your knowledge, are you pregnant (or do you think you could be)? Circle one. Yes No Possibly/Not Sure

PATIENT STATEMENT AND RELEASE

I certify that the above information is true and correct to the best of my ability. If I have represented that I am or may be pregnant, and if I have chosen to proceed with the radiology procedure(s) planned for me, I am acknowledging that I am accepting the risks of radiation exposure to the fetus and hereby release and hold harmless the radiologist(s) and radiology staff and their employer(s), agents and assigns, from any and all liability for consequences of radiation exposure to the fetus. I understand that if measures to shield the fetus are feasible with the procedure(s) I am to have, that such measures will be utilized. I also understand that no guarantee has been made to me regarding the effectiveness of shielding in my circumstances.

Patient Signature: _____ **Date:** _____ **Consent obtained by:** _____

Pregnancy Test Performed as Needed in Diagnostic Imaging

Verbal consent to test from: ____Patient ____Guardian

Results: ____Negative ____Positive

Testing tech/nurse initials:_____

Pregnancy Test Performed Outside the Department

Test date: _____

Results: ____Negative ____Positive

Source of results: _____

INFORMED CONSENT FOR X-RAY EXAMINATIONS OF PREGNANT OR POTENTIALLY PREGNANT PATIENT

PATIENT: _____ **MRN:** _____

DATE: _____ **TIME:** _____

To the patient:
This informed consent form applies only to single examination diagnostic radiographic studies and single-phase abdominal-pelvic CT studies. You are scheduled for an X-ray examination of your body. You and your unborn child will be exposed to X-rays. The risk to you is very small. The examination might slightly increase the possibility of cancer later in the child's life, but the actual potential for a healthy life is very nearly the same as that of other children in circumstances similar to yours. The examination does not add to risks for birth defects. Your physician has considered the risks associated with this examination and believes it is in your and your child's best interests to proceed. Any questions you have regarding this examination should be directed to the radiologist.

Radiologist or referring physician:_____ Date:_____

I, _____, have read and fully understand the above and hereby give my consent to have an X-ray procedure performed. I have been informed of the estimated risks to my embryo or fetus.

Patient/guardian signature:_____ Date:_____

10.1.3 Training for Technologists Under Supervision of Authorized Human Use User

All personnel who will be authorized to handle radioactive material must be qualified through training and experience to use the material in question for the purpose requested, and in such a manner as to minimize danger to public health and safety or the environment. Individuals must be certified as a general certificate medical radiologic technologist (MRT) under Texas Occupations Code Chapter 601, Medical Radiographic Technologists (MRT). See 25 TAC §140.

Eligibility of application for MRT includes (but not limited to):

A. Certified by the Nuclear Medicine Technologist Certification Board (NMTCB); or
B. Certified in nuclear medicine by the American Registry of Radiologic Technologists [ARRT(N)]; or
C. Have completed the NMTCB's examination in nuclear medicine technology; or
D. Have completed the ARRT's examination in radiography, radiation therapy, or nuclear medicine technology; or
E. Currently licensed or otherwise registered as a medical radiologic technologist in another state, the District of Columbia, or a territory of the United States whose requirements are more stringent than or are substantially equivalent to the requirements for Texas certification; or
F. Have completed training in accordance with the outline in Appendix A, "Minimum Training Criteria for Cross Training Registered X-Ray Technologists for Nuclear Medicine." [NOTE: Registered X-Ray Technologists are currently registered by the American Registry of Radiologic Technologists.] If hiring an individual with this type of documentation, the prior training could be considered acceptable without need for additional training if the scope of practice was equivalent to that of the original training; or
G. Have any other documentation acceptable to the Department of State Health Services
H. See 25 TAC §140 for applicability and eligibility for Temporary MRT

10.2 Release of Patients Containing Radiopharmaceuticals

The following applicable release condition must be met for a patient containing radioactive material:

A. Any individual to whom more than 30 millicuries of a radiopharmaceutical is administered shall be confined to an approved inpatient facility and shall not be released from confinement until the activity of the administered radiopharmaceutical in the patient is less than 30 millicuries or the dose rate at one meter from the patient is less than 5 millirem per hour;
B. The physician will have ultimate responsibility on patient release criteria.

10.3 Use of Dose Calibrators

Dose calibrators used for determining patient dosage should be calibrated in accordance with the manufacturer’s instructions and the following schedule:

A. Daily for constancy, when in use.
B. Quarterly for linearity over the range that it is normally used.
C. Annually for complete calibration.

A log of calibrations should be maintained by the user.

10.4 Positron-Emitting Radionuclides - Special Precautions

A. Appropriate lead shielding should be maintained when preparing, storing, or using positron-emitting radionuclides.

B. Minimize exposure by utilizing available protective equipment and minimizing handling time. Traditional lead-shielded syringes provide little attenuation for the 511 keV photons, and may hinder the administration process. Novel plastic-shielded syringes attenuate the high-energy positrons emitted. Such protective devices should be considered in order to reduce employee exposures while maximizing patient care activities.
C. Routinely survey clinical facilities using positron-emitting radionuclides with a survey meter. The survey frequency for these laboratories will be conditionally determined accounting for radionuclides and activities utilized, available facilities, technological advances, or other mitigating circumstances.
D. Keep sources used for attenuation correction or standardization behind lead shielding at all times excluding use.
E. Additional individual monitoring devices may be required for employees in PET research. Historical dosimetry records of extremity, lapel, and other dosimeters will be used to determine monitoring criteria. This evaluation will account for significant changes in patient load, radionuclides and activities present, and other necessary data.
F. In the event of a radioactive material spill, follow standard emergency response or decontamination procedures stated in Section "13. Incidents and Emergencies". Contact the RSP for assistance with response, decontamination, and radiation level quantification.

11. Sealed Sources of Radioactive Material

A sealed source of radioactive material is defined as radioactive material that is permanently bonded or fixed in a capsule or matrix designed to prevent release and dispersal of the radioactive material under the most severe conditions that are likely to be encountered in normal use and handling. Sources fabricated by individuals or organizations who are not registered and approved by the Sealed Source and Device Registry maintained by the U.S. Nuclear Regulatory Commission are not considered sealed sources. Radioactive sources which are not registered and approved should be treated as unsealed sources and subject to the handling precautions and requirements for open radionuclides.

11.1 General Requirements

A. Each sealed source, unless otherwise exempt, shall be tested for leakage or contamination and the test results available before the sealed source is put into use unless a certificate from the transferor indicates that the sealed source has been successfully leak tested within the required leak test interval.
B. Each sealed source that is not designed to emit alpha particles is tested for leakage or contamination at intervals not to exceed six months or at alternative intervals approved by the DSHS RCP.
C. Each sealed source that is designed to emit alpha particles is tested for leakage or contamination at intervals not to exceed three months or at alternative intervals approved by the DSHS RCP.
D. If a sealed source is required to be surveyed for leakage and the source is damaged or suspected of leaking, the sealed source should be surveyed for leakage or contamination.
E. Tests for leakage for all sealed sources, except radium brachytherapy sources, shall be capable of detecting the presence of 0.005 microcurie (11,100 dpm) of radioactive

material on a test sample. Test samples should be taken from the sealed source or the surfaces of the storage container where contamination might accumulate.

F. Analysis for sealed source leak tests should be performed by the RSP under the guidance of the RSO. Additional sealed source tests may be performed by authorized vendors or the source manufacturer.
G. The following shall be considered indication that a sealed source is leaking:
    1. The presence of 0.005 microcurie (11,100 dpm) or greater of removable contamination originating from the source tested;
H. Upon determination that a sealed source is leaking, the Radiation Safety Program will remove the leaking source to prevent personnel contamination. The leaking source will be either repaired or disposed according to the 25 TAC.
I. The Radiation Safety Program must notify the DSHS RCP if a sealed source is determined to be leaking. A written report of a leaking source shall be submitted to the DSHS RCP within five working days of the determination that the source is leaking.
J. An inventory of sealed sources will also be conducted.

11.2 Exemptions

Tests for leakage or contamination are not required on the following sealed sources:

A. Sealed sources containing only radioactive material with a half-life less than 30 days;
B. Sealed sources containing only radioactive material as a gas;
C. Sealed sources containing 100 microcurie or less of beta- or photon-emitting material or 10 microcurie or less of alpha-emitting material;
D. Sealed sources containing only ^{3}H;
E. Seeds of ^{192}Ir encased in nylon ribbon; and
F. Sealed sources which are stored, not being used and identified as in storage.

12. Instruction and Training

All operations in which there is the probability of exposure to ionizing radiation shall be supervised or directed by an individual who is competently aware of the potential hazards involved and who is capable of minimizing these hazards. The RSC encourages Authorized Users to avail themselves of every opportunity to improve the professional proficiency of their technicians, research associates, students, and other laboratory personnel under their supervision through formal and informal instruction in the practice of radiation safety.

Written safety procedures established for laboratory operations and a copy of the *Radiation Safety Manual* must be available to laboratory personnel. All applicable individuals working in the laboratory will be required to familiarize themselves with these procedures and practice them. In addition, it is incumbent upon the Authorized User or the laboratory supervisor to ensure that such persons are familiar with established safety procedures. Applications for authorization to use radioactive materials and requests to add new personnel to a project require individuals associated with the project to indicate such familiarity was established.

Periodically, the Radiation Safety Program offers instruction sessions or seminars about the fundamentals of laboratory radiation protection to technicians, applicants for radioactive materials use, and other interested persons. It is emphasized that completion of a formal course in radiation safety does not absolve an Authorized User from the obligation of instructing technicians in the principles of good radiation safety practices.

Individuals performing radioactive material protocols may complete one of the following options:

A. Attend training offered by the Radiation Safety Program
B. Provide to the Radiation Safety Program a copy of a certificate or letter of completion for a course on radiation safety from another U.S. institution; or
C. Successfully complete an examination on radiation safety given by the Radiation Safety Program.

13. Incidents and Emergencies

13.1 General Information

The University of Texas Health Science Center at Houston ***Emergency Management Plan (EMP)*** provides a clearly defined protocol and corresponding support mechanism to protect UTHealth Houston personnel and property in emergency situations. The scope of this plan is to define emergency situations, specific preventive and response procedures to avoid and cope with emergencies in a safe, orderly and efficient manner, protecting the personnel and facilities at UTHealth Houston. Emergency situations include any circumstances that threaten UTHealth personnel and/or property.

A complete publication of The University of Texas Health Science Center Emergency Management Plan is available in all Dean's offices. The most current *EMP* is also available online at https://www.uth.edu/safety/occupational-safety-and-fire-prevention/emergency-procedures.htm or https://www.uth.edu/safety/manuals-and-forms.htm.

13.2 Minor Spills

A. Notify the RSP or UT Police of the spill. The following information is necessary:
   1. Laboratory location of the spill, including building & room number;
   2. Identity of the caller;
   3. Extent of personnel injuries;
   4. Radionuclide involved;
   5. Amount of radioactive material involved (in μCi); and
   6. The chemical or physical form.
B. If the spill occurs:
   1. **During working hours** - call Radiation Safety 713-500-5840.
   2. **After working hours** - call UT Police dispatch at 713-792-2890.
C. Attend to the spill as soon as possible.
D. Use appropriate personal protective equipment (e.g. gloves, laboratory jacket, etc.).
E. Once the affected area has been blotted dry, scrub the contaminated area with radcon, shaving cream, scrubbing bubbles or soap and water. Continue this process until the contamination is less than 1,000 dpm/100 cm^2 of the removable contamination. If the contaminated area cannot be reduced to these levels, the area should be covered with an impervious material (e.g. diaper paper) to prevent further contamination. If the spill produces radiation fields exceeding 2 mrem/hr at one foot from the source, appropriate shielding material should be placed on the area. If shielding is not feasible, access to the spill zone should be restricted. All areas of non-removable contamination should be labeled with cautionary information, and personnel in the area should be notified. The RSP is available to supervise personnel concerning decontamination of surfaces, appropriate shielding, and restriction of access.

F. In the case of contaminated wounds, rinse with running water and soap. (Do not scrub contaminated skin). Cover with sterile dressing and seek medical attention at once.

13.3 Major Spills or Radiation Emergencies

Radiation emergencies are incidents which involve actual or suspected exposure to uncontrolled sources of radioactivity that cause or threaten to cause an external dose in excess of twenty-five (25) rem to the whole body, or gross radioactive personnel contamination resulting in ingestion, inhalation, injection, or skin absorption of radioactive material leading to comparable risk.

A. Call UT Police dispatch at 713-792-2890.
B. Provide the following information to UT Police:
    1. Laboratory location of the spill or emergency;
    2. Identity of the caller;
    3. Extent of personnel injuries;
    4. Radionuclide involved;
    5. Amount of radioactive material involved (in μCi); and
    6. The chemical or physical form.
C. Life-saving or first aid measures take precedence over radiation hazards and decontamination efforts.
D. Stand clear of a contaminated area.

13.4 Laboratory Fires

In the event of a laboratory fire, the following procedure is recommended:

A. Report the fire by calling 911 or UT Police dispatch at 713-792-2890. The following information should be given:
    1. Identify yourself and phone number;
    2. Exact location of fire (building, laboratory number of the specific area);
    3. Extent of personnel injuries;
    4. Type of fire (electrical, flammable liquid, trash, *etc*.); and
    5. Extent of fire (severity of fire and smoke).
B. Close laboratory doors to contain the fire as you leave the laboratory area.
C. Activate the fire alarm system as you exit to the stairwell. Fire alarm pull stations are generally located near stairwells.
D. Evacuate to safe area after exiting through the stairwell.

13.5 Defining Incidents and Emergencies

The following may constitute an incident or emergency:

A. Loss or theft of any radioactive material or radiation producing device.
B. High or potentially high radiation exposure to an employee or member of the general public. For example:
    1. Greater than 1,000 mrem whole-body in one month to an occupationally exposed individual;
    2. Greater than 10,000 mrem in one month to the extremities of an occupationally exposed individual; or
    3. Greater than 100 mrem to any member of the general public.
C. Intake of radioactive material by inhalation, ingestion, skin absorption, or injection through the skin or wound.
D. Deceptive or potentially deceptive exposure of a dosimeter.

E. Personnel contamination which cannot be removed after two washes with soap and water.
F. Spills involving significant activities of ^{125}I or ^{131}I with the potential for inhalation.
G. Removable contamination in unrestricted areas (e.g. hallways, offices, vehicles, etc.) which exceed the limits outlined in *25 TAC §289.202 (o)(2)(B)(ii)*.
H. Radiation fields in unrestricted areas which exceed the limits specified for members of the general public in *25 TAC §289.202 (o)(2)(B)(i)*.
I. Accidental or unmeasured releases of radioactive material to the environment.
J. Fire or floods which threaten to release radioactive material to the environment or which threaten to expose emergency response personnel.
K. An on-site transportation accident involving radioactive material.
L. Personnel injuries which may involve radioactive material contamination of the wound.
M. Additional situations deemed pertinent by the RSC or RSO/ARSO.

14. Recordkeeping

14.1 General Requirements

A. The RSP shall maintain all required records in units and sub-divisions of curie, rad, rem, roentgen, or disintegrations per minute, where appropriate and/or feasible.
B. All units shall be clearly indicated on required records.
C. The RSP shall make distinction among quantities and values entered on required dosimetry records (e.g. total effective dose equivalent, total organ dose equivalent, shallow dose equivalent, eye dose equivalent, deep dose equivalent, or committed dose equivalent).
D. Required records shall include the date and identification of the individual making the record, and, as applicable, a unique identification of the survey instrument(s) used, and an exact description of the survey location.
E. Records of receipt, transfer, and disposal of sources of radiation shall uniquely identify the radiation source.
F. Record retention rates for documents not specified will be determined on a case by case basis.

15. Glossary of Terms

ABSORBED DOSE: The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material. The unit of absorbed dose is the rad, where 1 rad = 10^{-5} J/gram.

ABSORPTION: The phenomenon by which radiation imparts some or all of its energy to any material through which the radiation passes.

ACTIVITY: The number of nuclear disintegrations occurring in a given quantity of material per unit time.

ACUTE EXPOSURE: Term used to denote a relatively high radiation exposure of short duration.

ALARA: Acronym for the radiation protection philosophy that radiation exposures and effluents to the environment should be maintained "As Low As Reasonably Achievable". The U.S. Nuclear Regulatory Commission requires that ALARA be considered in the design of all experiments where radioactive material is used.

ALARA LEVEL: Administrative action level of 2.5% of any applicable dose limit.

ALPHA PARTICLE: A strong ionizing particle emitted from the nucleus during radioactive decay, having a mass and charge equal in magnitude to a helium nucleus, consisting of 2-protons and 2-neutrons with a double positive charge.

ATOM: Smallest particle of an element that is capable of entering into a chemical reaction.

ATOMIC NUMBER: The number of protons in the nucleus of an atom.

ATTENUATION: The process by which a beam of radiation is reduced in intensity when passing through materials.

AUTHORIZED USER: An individual member of the teaching or research faculty or professional staff who has been approved by the Radiation Safety Committee to use or supervise the use of radioactive material under conditions specified in an application for authorization. All transactions involving radioactive material must be made in the name of an Authorized User.

BACKGROUND RADIATION: Ionizing radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in other parts of the building, in the building material itself, etc.

BACKSCATTER: The deflection of radiation by scattering processes through angles greater than 90 degrees with respect to the original direction of motion.

BEAM: A unidirectional or approximately unidirectional flow of electromagnetic radiation or particles: A *USEFUL BEAM* in radiology is that part of the primary radiation that passes through the aperture, cone, or other collimator.

BECQUEREL (Bq): SI Unit of radioactivity. One Bq equals one nuclear transformation/second. One microcurie is equivalent to 37,000 Bq (37 kilobecquerels) (kBq). 1 μCi = 37,000 Bq = 37 kBq.

BETA PARTICLE(β): Charged particle emitted from the nucleus of an atom, having a mass and charge equal in magnitude to that of the electron.

BIOASSAY: Monitoring of personnel for the uptake of radioactive material in the body.

BIOLOGICAL HALF-LIFE: The time required for the body to eliminate one-half of an administered dose of any substance by regular processes of elimination. This time is

approximately the same for both stable and radioactive isotopes of a particular element.

BONE SEEKER: Any compound or ion which migrates in the body preferentially into bone.

BREMSSTRAHLUNG: Electromagnetic (X-ray) radiation associated with the deceleration of charged particles passing through matter. Usually associated with energetic beta emitters, (e.g., phosphorus-32).

CALIBRATION: Determination of variation from standard, or accuracy, of a measuring instrument to ascertain necessary correction factors.

COLLIMATOR: A device for confining the elements of a beam within an assigned solid angle.

CONTAMINATION, RADIOACTIVE: Deposition of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful. The harm may be in vitiating the validity of an experiment or a procedure, or in actually being a source of excess exposure to personnel.

COUNT (Radiation Measurements): The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total registered in a given period of time. The term is often erroneously used to designate a disintegration, ionizing event, or voltage pulse.

CRITICAL ORGAN: That organ or tissue, the irradiation of which will result in the greatest hazard to the health of the individual or his descendants.

CURIE: The quantity of any radioactive material in which the number of disintegrations is 3.700×10^{10} disintegrations per second. Abbreviated Ci.

DECAY, RADIOACTIVE: Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

DISINTEGRATION: A spontaneous nuclear transformation (radioactive) characterized by the emission of energy and/or mass from the nucleus. When large numbers of nuclei are involved, the process is characterized by a definite half-life.

DOSE: A general term denoting the quantity of radiation or energy absorbed in a specified mass. For special purposes, it must be appropriately qualified, (e.g., absorbed dose).

DOSE, ABSORBED: The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad, which is 10^{-5} J/gram.

DOSE EQUIVALENT: A quantity used in radiation protection expressing all radiation on a common scale for calculating the effective absorbed dose. The unit of dose equivalent is the rem, which is numerically equal to the absorbed dose in rads multiplied by certain modifying factors such as the quality factor, the distribution factor, etc.

DOSE RATE: Dose delivered per unit time.

DOSIMETER: An instrument used to detect and measure an accumulated dose of radiation. In common usage, it is a pencil size ionization chamber with a built-in self-reading electrometer or other measuring deceive used for personnel monitoring.

DOT: Department of Transportation (U.S.).

EFFICIENCY (Counters): A measure of the probability that a count will be recorded when radiation is incident on a detector. Usage varies considerably so it is well to make sure which factors (window, transmission, sensitive volume, energy dependence, etc.) are included.

ELECTRON: Negatively charged elementary particle that is a constituent of every neutral atom. Its unit of negative electricity equals 4.8×10^{10} electrostatic units or 1.6×10^{19} coulombs. Its mass is 0.000549 atomic mass units.

ELECTRON VOLT: A unit of energy equivalent to the amount of energy gained by an

electron in passing through a potential difference of 1 volt. Abbreviated eV. Larger multiple units of the electron volt frequently used are: keV for thousand or kiloelectron volts, MeV for million electron volts, and BeV for billion electron volts.

EPP: The Environmental Protection Program (EPP) within the Safety, Health, Environment and Risk Management department of UTHealth provides support for the environmental and waste aspects of radiation use at UTHealth.

ERYTHEMA: An abnormal redness of the skin due to distention of the capillaries with blood. It can be caused by many different agents-heat, drugs, ultraviolet rays, or ionizing radiation.

EXPOSURE: A measure of the ionization produced in air by X or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of air in the volume element. The special unit of exposure is the roentgen.

GAMMA RAY: Very penetrating electromagnetic radiation of nuclear origin. Except for origin, identical to X-ray.

GEIGER-MUELLER (GM) COUNTER: Highly sensitive gas-filled detector and associated circuitry used for radiation detection and measurement.

GRAY (Gy): SI unit of absorbed dose. 1 Gy is 1 Joule of energy deposited per kilogram of absorber. 1 Gy is equivalent to 100 rad.

HALF-LIFE, EFFECTIVE: Time required for a radioactive nuclide in a system to be diminished 50 percent as a result of the combined action of radioactive decay and biological elimination.

$$\text{Effective half-life} = \frac{\text{Biological halflife x Radioactive halflife}}{\text{Biological halflife} + \text{Radioactive halflife}}$$

HALF-LIFE, RADIOACTIVE: Time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life

HALF VALUE LAYER (Half thickness): The thickness of any specified material necessary to reduce the intensity of an X-ray or gamma ray beam to one-half its original value.

HEALTH PHYSICS: A term in common use for that branch of radiological science dealing with the protection of personnel from harmful effects of ionizing radiation.

HIGH RADIATION AREA: Any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirems. High Radiation Areas must be posted and must be equipped with specified control devices, alarms, etc.

HOOD, FUME: A hood for handling unconfined radioactive materials that provides adequate containment in a hood or box and independent air exhaust from the work area.

INVERSE SQUARE LAW: The intensity of radiation at any distance from a point source varies inversely as the square of that distance. For example, if the radiation exposure is 100 R/hr at 1 inch from a source, the exposure will be 0.01 R/hr at 100 inches.

IODINATION: To combine or treat with iodine or a compound of iodine.

IONIZATION: The process by which a neutral atom or molecule acquires either a positive or a negative charge.

IONIZING RADIATION: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

ISOTOPES: Nuclides having the same number of protons in their nuclei, and hence having the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element.

LABELED COMPOUND: A compound consisting, in part, of molecules labeled by radioactive material. By observations of radioactivity or isotopic composition this compound or its fragments may be followed through physical, chemical, or biological processes.

LEAK TEST: A test for leakage from sealed radioactive sources (usually a wipe test) when received and on a periodic basis.

LEAKAGE RADIATION: The radiation which escapes through the protective shielding of an X-ray tube or teletherapy unit.

LIQUID SCINTILLATION COUNTER (LSC): See SCINTILLATION COUNTER.

MONITORING, RADIOLOGICAL: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection. Area monitoring is routine monitoring of the level of radiation or of radioactive contamination of any particular area, building, room, or equipment. Personnel monitoring is monitoring any part of an individual, the individual's breath, the individual's excretions, or any part of the individual's clothing. (See Radiological Survey)

NATURAL RADIATION: The radioactivity exhibited by more than fifty naturally occurring radionuclides.

NEUTRON: Elementary particle with a mass approximately the same as that of a hydrogen atom and electrically neutral. It has a half-life in minutes and decays in a free state into a proton and an electron.

NUCLIDE: A species of atom characterized by its mass number, atomic number, and energy state of its nucleus, provided that the atom is capable of existing for a measurable time.

PLATED SOURCE: Radioactive material permanently deposited on a surface or matrix such that there is no window or other covering between the radioactive material and the open air. (Essentially a "sealed source" with a zero thickness window).

PRACTITIONER OF THE HEALING ARTS: A person licensed to practice healing arts by either the Texas State Board of Medical Examiners, the Texas Board of Dental Examiners, the Texas Board of Chiropractic Examiners, or the Texas Board of Podiatry Examiners.

PROTECTIVE BARRIERS: Barriers of radiation absorbing material; such as lead, concrete, plaster, and plastic, that are used to reduce radiation exposure.

PROTECTIVE BARRIERS, PRIMARY: Barriers sufficient to attenuate the useful beam to the required degree.

PROTECTIVE BARRIERS, SECONDARY: Barriers sufficient to attenuate stray or scattered radiation to the required degree.

QUALITY FACTOR (QF): Modifying factor by which absorbed doses are multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiations, the biological effectiveness of the absorbed dose termed the dose equivalent. As a rule of thumb, QF is 1 for X-rays, gamma rays, and Beta particles, and 20 for alphas. The quality factor for neutrons of known energy varies by energy and is found in *25 TAC §289.201(n)(2)*.

RAD: Acronym for "Radiation Absorbed Dose." The unit used to describe dose in terms of energy deposited in any absorber. 1 rad = 100 ergs/gram.

RADIATION: 1. The emission and propagation of energy through space or through a material medium in the form of waves, for instance, the emission and propagation of electromagnetic waves, or of sound and elastic waves. 2. The energy propagated through a material medium as waves; for example, energy in the form of electromagnetic waves or of elastic waves. The term "radiation" or "radiation energy" when unqualified, usually refers to electromagnetic

radiation. Such radiation commonly is classified according to frequency as Hertzian, infrared, visible (light), ultraviolet, x-ray, and gamma ray. 3. By extension corpuscular emissions, such as alpha and beta radiation, or rays of missed or unknown type, as cosmic radiation.

RADIATION AREA: Any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 millirems, or in any 5 consecutive days a dose in excess of 100 millirems.

RADIATION SAFETY OFFICER (RSO): An officer established under the *TAC* who is responsible for investigating incidents, monitoring, and implementing policies on matters relating to radiation safety and is the Radiation Safety Committee's authorized representative regarding radiation protection within the UTHealth. The RSO directs the Radiation Safety Program and the radiation aspects of the Environmental Protection Program at the UTHealth. If designated, the Associate Radiation Safety Officer (ARSO) also directs the Radiation Safety Program as well.

RADIOACTIVE DECAY: Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

RADIOACTIVITY: Process whereby certain nuclides undergo spontaneous disintegration in which energy is liberated, generally resulting in the formation of new nuclides. The process is accompanied by the emission of one or more types of radiation.

RADIOISOTOPE: Nuclides having the same number of protons in their nuclei; and hence, the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element. The term should not be used as a synonym for nuclide.

RADIOLOGICAL SURVEY: Evaluation of the radiation hazards incident to the production, the use or the existence of radioactive materials or other sources of radiation under a specific set of conditions. Such an evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

RADIONUCLIDE: A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons (Z), the number of neutrons (N), and the energy content; or alternatively, by the atomic number (Z), by the mass number A=(N+Z), and by the atomic mass. To be regarded as a distinct nuclide, the atom must be capable of existing for a measurable time. Thus, nuclear isomers are separate nuclides, whereas promptly decaying excited nuclear states and unstable intermediates in nuclear reactions are not so considered.

RAM: Abbreviation for radioactive material.

REM: The special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor, by the distribution factor, and by any other necessary modifying factors.

RESPIRATOR: A device worn over the nose and mouth to protect the respiratory tract from contaminated atmospheres.

RESTRICTED AREA: Any area, access to which is controlled for purposes of protection of individuals from exposure to radiation and radioactive materials. While any area except areas used for living quarters may be designated as a restricted area, every area in which

there are radiation levels, which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days *must* be established as a restricted area.

ROENTGEN (R): The quantity of x or gamma radiation such that the associated corpuscular emission per 0.001293 grams of dry air produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign. The roentgen is the special unit of exposure.

RSP: The Radiation Safety Program (RSP) within the Safety, Health, Environmental and Risk Management department of UTHealth provides radiation safety support to the Radiation Safety Officer and the Radiation Safety Committee.

SCATTER: Change of direction of sub-atomic particle or photon as a result of a collision or interaction. MULTIPLE: Scattering of a particle or photon in which the final displacement is the vector sum of many, usually small displacements.

SEALED SOURCE: Radioactive material permanently enclosed inside a capsule or other holder such that there is no contact between the radioactive material and the open air. Sealed sources must be tested for leakage at intervals specified in the NRC license.

SHIELDING MATERIAL: Any material that is used to absorb radiation and thus effectively reduce the intensity of radiation, and in some cases eliminate it. Lead, concrete, aluminum, water, and plastic are examples of commonly used shielding material.

SI: Abbreviation for the international system of units. A system of units rapidly being adopted throughout the world. The terms gray, sievert, becquerel, and coulomb per kilogram are all SI units.

SIEVERT (Sv): SI unit of absorbed dose to the human body in terms of biological effect. (sievert is gray x QF.) 1 Sv is equivalent to 10 Rem.

WHOLE-BODY EXPOSURE: Exposure to ionizing radiation of the whole body or trunk and major blood-forming organs.