Texas Tech University Health Sciences Center

Radiation Safety Manual

Revised November 2003

Statement of Acknowledgment

I have received, read, and understand the information contained in the Texas Tech University Health Sciences Center *Radiation Safety Manual*, and I am familiar with the provisions of applicable federal, state, and local rules and regulations regarding the possession and use of radioactive material and/or radiation-producing devices.

Statement of Agreement

I agree to observe and comply with the provisions of the Texas Tech University Health Sciences Center *Radiation Safety Manual* and applicable federal, state, and local rules, regulations, and procedures regarding the possession and use of radioactive material and/or radiation-producing devices.

Texas State Government Privacy Policies (Government Code):
1) With few exceptions, you are entitled on request to be informed about the information the state governmental body collects about you; 2) Under Section 552.021 and 552.023, you are entitled to receive and review the information; and 3) Under Section 552.004, you are entitled to have the state governmental body correct information about you that is incorrect.

The Texas Tech University Health Sciences Center *Radiation Safety Manual* must be reviewed and this signature page must be signed and dated annually

Printed Name	Signature	Date

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TEXAS TECH UNIVERSITY HEALTH SCIENCES CENTER

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From the President . . .

Radiation Safety is the responsibility of all faculty, staff and students who may be directly or indirectly involved in the use of radioactive material or radiation-producing devices within Texas Tech University Health Sciences Center (TTUHSC), including Regional Campuses.

In July 1975, the State of Texas granted Texas Tech University Health Sciences Center, including Regional Campuses, a broad-scope Radioactive Material License. TTUHSC agreed to establish and maintain an effective Radiation Safety Program. The TTUHSC Radiation Safety Committee is responsible for implementing the TTUHSC Radiation Safety Program, as outlined in this manual.

The use of radiation within an environment where a large number of people may be unaware of the potential of exposure to radiation hazards, requires strict commitment to guidelines and procedures established by federal, state, and local regulatory agencies and the TTUHSC Radiation Safety Committee, to insure the safety of faculty, staff, students, and the general public, as well as the protection of TTUHSC and the environment.

It is the responsibility of all faculty, staff and students involved in work with radioactive material or radiation-producing devices to become thoroughly familiar with the provisions of the TTUHSC Radiation Safety Program and all applicable federal, state, and local rules and regulations.

Radiation Safety is dependent on the radiation user's continual awareness of potential hazards associated with the use of radiation. Radiation users should make every reasonable effort to keep exposures ALARA (As Low As Reasonably Achievable) for both occupationally exposed personnel and the general public.

M. Roy Wilson, M.D., M.S.
President

Table of Contents

List of Acronyms and Abbreviations

ALARA	As Low As Reasonably Achievable
Bq	Becquerel
RC	Radiation Control
CFR	Code of Federal Regulations
Ci	Curie
cpm	Counts per Minute
cps	Counts per Second
dpm	Disintegrations per Minute
dps	Disintegrations per Second
FDA	Food and Drug Administration
Gy	Gray
HSC	Health Sciences Center
HVL	Half-value layer
IRB	Institutional Review Board
keV	Kilo Electron Volts
LET	Linear Energy Transfer
LSC	Liquid Scintillation Counter
LSV	Liquid Scintillation Vials
MeV	Mega Electron Volts
MPD	Maximum Permissible Dose
NCRP	National Council on Radiation Protection and Measurements
NRC	Nuclear Regulatory Commission
OSL	Optically Stimulated Luminescence (Dosimeter)
R	Roentgen
RAD	Radiation Absorbed Dose
REM	Radiation (Roentgen) Equivalent Man
RIA	Radioimmunoassay
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer
RSS	Radiation Safety Services
RSSA	Radiation Safety Services – Amarillo
SI	International System of Units
SS	Safety Services
TDSHS	Texas Department of State Health Services
TDSHS-RC	Texas Department of State Health Services, Radiation Control
TLD	Thermoluminescent Dosimeter
TRCR	Texas Regulations for Control of Radiation
TTUHSC	Texas Tech University Health Sciences Center

Common Measurements and Units of Measure

Bq	Becquerel – 1.0 disintegrations per second
c	centi (prefix) – $1.0E^{-2}$ (0.01)
Ci	Curie – $3.7E^{10}$ disintegrations per second
cpm	counts per minute
cps	counts per second
d	deci (prefix) – $1.0E^{-1}$ (0.1)
da	deca (prefix) – $1.0E^{1}$ (10)
dpm	disintegrations per minute
dps	disintegrations per second
f	femto (prefix) – $1.0E^{-15}$ (0.000000000000001)
G	giga (prefix) – $1.0E^{9}$ (1,000,000,000)
Gy	Gray – 1.0 joule per kilogram (J/kg) (100 rad)
h	hecto (prefix) – $1.0E^{2}$ (100)
k	kilo (prefix) – $1.0E^{3}$ (1,000)
m	milli (prefix) – $1.0E^{-3}$ (0.001)
M	mega (prefix) – $1.0E^{6}$ (1,000,000)
MeV	million electron volts
n	nano (prefix) – $1.0E^{-9}$ (0.000000001)
p	pico (prefix) – $1.0E^{-12}$ (0.000000000001)
P	peta (prefix) – $1.0E^{15}$ (1,000,000,000,000,000)
R	Roentgen – $2.58E^{-4}$ coulombs per kilogram (C/kg) of air
rad	100 ergs per gram (erg/g) or 0.01 J/kg (0.01 gray)
rem	absorbed dose (rad) multiplied by quality factor [0.01 sievert (Sv)]
Sv	Sievert -
T	tera (prefix) – $1.0E^{12}$ (1,000,000,000,000)
V	volt

α	alpha
β	beta
γ	gamma
μ	micro (prefix) – $1.0E^{-6}$ (0.000001)

Inverse-square formula (for calculating dose reduction due to distance): $I_2 = \frac{I_1 \times (d_1)^2}{(d_2)^2}$

Where: I_1 = Intensity at distance 1 (d_1)
I_2 = Intensity at distance 2 (d_2)
d_1 = Distance nearest to source
d_2 = Distance farthest from source

Radioactive decay formula (for calculating activity remaining): $A = A_0 e^{-\lambda t}$

Where: A_0 = Original activity of radioactive material (at assay date)
e = The base of the natural logarithm (2.718)
λ = The decay constant $\left(\frac{\ln 2}{half - life}\right)$
t = Time expired since assay date
A = Remaining activity

Note: Time units must be the same for half-life and time expired.

cpm – dpm conversion: $dpm = \frac{cpm}{efficiency}$

Where: dpm = disintegrations per minute
cpm = counts per minute
$efficiency = \frac{Efficiency(percent)}{100}$

Curie – Becquerel conversion: $Bq = Ci \times \left(3.7 \times 10^{10}\right)$

Where: Bq = Becquerel
Ci = Curie

millicurie – Bequerel conversion: $Bq = mCi \times \left(3.7 \times 10^{7}\right)$

Where: Bq = Bequerel
mCi = millicurie

Bequerel – Curie conversion: $Ci = \frac{Bq}{3.7 \times 10^{10}}$

Bequerel – millicurie conversion: $mCi = \frac{Bq}{3.7 \times 10^{7}}$

Texas Tech University Health Sciences Center

Radiation Safety Manual

Section 1 Administration

1.1 General

(a) The use of radioactive material and other sources of radiation at Texas Tech University Health Sciences Center (TTUHSC) is authorized by Texas Department of State Health Services, Radiation Control, Radioactive Material License Number L01869. This academic broad-scope license authorizes possession of radioactive material with an atomic number of less than 84, activity levels of up to 300 millicuries for each radioactive isotope, and possession of various other specific radioactive materials and activity levels. A copy of the Radioactive Material License is available for review and inspection at TTUHSC, Radiation Safety Services, 3601 4th Street, STOP 9020, Room BA120, Lubbock, TX 79430-9020.

(b) Texas Department of State Health Services, Radiation Control (TDSHS-RC) holds authority for granting radioactive material licenses and registrations, and has established regulatory guidelines for the possession, handling, and use of radioactive material, as well as guidelines for the protection of individuals from radioactive exposure in Texas. The regulations are found in 25 Texas Administrative Code (TAC) §289, "Texas Regulations for Control of Radiation."

(c) X-ray machines, electron microscopes, and other radiation-producing machines, devices, and equipment must be registered with TDSHS-RC. Copies of applicable registrations are also available for review and inspection at the Radiation Safety Services office.

1.2 Radiation Safety Committee (RSC)

(a) The TTUHSC Radiation Safety Committee (RSC) shall meet the requirements of 25 TAC §289.252(g).

(b) The President (or designee) of TTUHSC shall appoint the Committee members and the Committee Chair of the TTUHSC Radiation Safety Committee. Each active Regional Campus subsite shall be represented on the RSC. The Radiation Safety Officer (RSO), Regional Campus Radiation Safety Coordinator (RCRSC), and Director of Safety shall be appointed as ex-officio, voting members of the Committee. Appointments are reviewed and approved by TDSHS-RC.

(c) The RSC shall conduct business in the manner prescribed in the "Bylaws of the Texas Tech University Health Sciences Center Radiation Safety Committee."

(d) The RSC holds responsibility for formulating policy, practice, and rules regarding the Radioactive Material License, including, but not limited to purchase, shipment, use, monitoring, disposal, and transfer of radioactive material or other

sources of ionizing radiation at TTUHSC, including active Regional Campuses. The primary function of the RSC is to ensure that the principles of radiation safety are observed, and to formulate or alter policy and practice to assure that the Radiation Safety Program meets the needs of the institution and the requirements of applicable regulations.

(e) The RSC will review the quarterly Radioactive Material Sublicense inspections for the month previous to the regularly scheduled Committee meeting, and will consider any enforcement action necessary regarding any discovered violations. If a violation is discovered during an inspection, the inspection history of the Sublicensee for the four previous calendar quarters is also reviewed. The committee, taking into account the severity of the violation and the inspection history of the Sublicensee, will judge each individual case on its own merit. Enforcement actions taken by the committee include, but are not limited to the following:

(1) A "Notice of Violation" letter signed by the Chair of the RSC may be sent to the Sublicensee, and the Sublicensee shall be required to respond in writing concerning the violation;

(2) Additional radiation safety training for the Sublicensee and research staff may be required;

(3) The Sublicensee may be required to attend the next regularly scheduled RSC meeting to address the violation;

(4) The Sublicensee may be placed on administrative probation for a period of one full year, with no significant violations occurring during this time period;

(5) The Radioactive Material Sublicense may be terminated immediately, and all radioactive material may be impounded.

(f) The RSC will normally meet on a monthly basis. A quorum shall be constituted as prescribed in the Committee bylaws. Regional Campus Committee members will normally attend RSC meetings via teleconference. Regional Campus Committee members shall be present when any agenda items affecting that subsite come before the RSC. Minutes of each RSC meeting shall be kept as a permanent record of Committee discussion, activity, and actions.

1.3 Radiation Safety Officer (RSO)

(a) The TTUHSC Radiation Safety Officer (RSO) shall meet the requirements of 25 TAC §289.252(f).

(b) The Radiation Safety Officer is responsible for implementation of policy, procedure, and regulatory requirements established by the RSC and TDSHS-RC. The TTUHSC Radiation Safety Program is administered through the Radiation Safety Services (RSS) office. The responsibilities of the RSO include, but are not limited to the following:

(1) Terminate any operation which the RSO determines to be causing a radiation hazard;

(2) Act as liaison between federal, state, and local radiation regulatory agencies, and the TTUHSC Radiation Safety Program, including all active Regional Campuses;

(3) Administer policy and procedure developed by the RSC for control of the procurement and utilization of radioactive material and other sources of ionizing radiation;

(4) Disseminate radiation safety and radiological health information to TTUHSC personnel and visitors, as appropriate;

(5) Prepare instructions to radiation workers to provide adequate radiation protection, and comply with applicable federal, state and local regulations;

(6) Perform formal, documented quarterly inspections of authorized radiation laboratory, utilization, and storage areas;

(7) Perform monthly audits of authorized radioactive laboratory, utilization, and storage areas to ensure that records of radiation surveys, inventory of radioactive material, and disposal of radioactive waste are maintained;

(8) Review all applications for, and amendments to, Radioactive Material Sublicenses;

(9) Provide advice and assistance to Radioactive Material Sublicense applicants in matters of radiation safety, and in procurement, utilization, storage, and disposal of radioactive material;

(10) Provide services for periodic calibration of radiation survey instruments, and maintain records of survey instrument calibration;

(11) Provide radioactive waste disposal for all radioactive material users;

(12) Maintain comprehensive files on receipt, utilization, storage and disposal of radioactive material, and all matters pertinent to the radiation control program;

(13) Perform radioactive sealed source inventory and leak tests as required by applicable regulations, and maintain inventory and leak test records;

(14) Provide personnel radiation exposure monitoring (dosimetry) services, including records of commercially processed radiation dosimetry device reports;

(15) Investigate and report (as appropriate) any unusual or excessive radiation exposures as required by applicable regulations;

(16) Report annually to the RSC on the status of the Radiation Safety Program at TTUHSC and all active Regional Campuses and clinics;

(17) Receive, inspect, process, and deliver all shipments of radioactive material entering or leaving the institution;

(18) Develop, present, and update as necessary, the "Radiation Safety Short Course" training program; and

(19) Obtain advice and guidance of the RSC for radiation safety matters not specifically addressed in the TTUHSC *Radiation Safety Manual*, except in extreme emergencies.

1.4 Regional Campus Radiation Safety Coordinator (RCRSC)

(a) The Regional Campus Radiation Safety Coordinator (RCRSC) is the designated representative of the RSO for the active Regional Campuses. The responsibilities of the Regional Campus Radiation Safety Coordinator include, but are not limited to the following:

(1) Terminate any operation which the RCRSC determines to be causing a radiation hazard;

(2) Disseminate information on radiation safety and radiological health;

(3) Perform monthly audits of authorized radioactive laboratory, utilization, and storage areas to ensure that records of radiation surveys, inventory of radioactive material, and disposal of radioactive waste are maintained;

(4) Receive, inspect, process, and deliver all shipments of radioactive material entering or leaving the Regional Campus;

(5) Provide radioactive waste disposal for all radioactive material users;

(6) Maintain comprehensive files on receipt, utilization, storage and disposal of radioactive material, and all matters pertinent to the radiation control program;

(7) Coordinate the use and distribution of personnel radiation exposure dosimetry devices; and

(8) Obtain advice and guidance of the RSO for radiation safety matters not specifically addressed in the TTUHSC *Radiation Safety Manual*, except in extreme emergencies.

1.5 Radioactive Material Sublicensee

(a) Each professional employee authorized to use radioactive material or other sources of ionizing radiation is responsible for the safe use of such materials and equipment. The responsibilities of the Radioactive Material Sublicensee include, but are not limited to the following:

(1) Observe all required administrative and radiation safety policies and procedures;

(2) Select and use those laboratory practices appropriate and applicable to the work being performed;

(3) Train and supervise professional staff and laboratory workers in applicable and appropriate radiation safety policy, procedures, and regulations, and ensure that these practices are observed in the radiation laboratory work area;

(4) Maintain records of receipt, utilization, transfer, storage and disposal of radioactive material;

(5) Maintain records of contamination surveys conducted in the radiation laboratory work area;

(6) Ensure that radiation laboratories are properly posted with appropriate radiation warning signs and notices as required by regulation; and

(7) Immediately notify the RSO of any unexpected or unusual situations that may affect the safety of personnel.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Section 2
Operational Guidelines

2.1 General

All users of radioactive material or other sources of radiation shall observe the following general guidelines:

(a) Each professional employee authorized to possess and use radioactive material or sources of radiation, is responsible for the safety of personnel and security of such material and equipment. The user (Sublicensee) shall carry out the required administrative and safety procedures, select laboratory practices appropriate for the work, train and supervise the laboratory staff in appropriate radiation safety practices, and ensure that these safe practices are observed.

(b) The Sublicensee shall maintain records of receipt, use, transfer, storage, and disposal of radioactive material, and of contamination surveys conducted in the radiation work areas.

(c) The Sublicensee shall ensure that radiation laboratory areas are posted with appropriate signs, labels, and warnings as required by applicable regulations.

(d) The Sublicensee shall immediately notify the Radiation Safety Officer (RSO) of situations or incidents that may affect the safety of personnel.

(e) The maximum permissible activity levels for unrestricted areas and the maximum permissible dose limits to individuals, as stated in applicable regulations, are to be considered the **absolute maximum limits**.

(f) Every effort shall be made to conduct experiments and operations involving radioactive material or sources of radiation in a manner that will maintain radiation exposures to personnel As Low As Reasonably Achievable (ALARA).

2.2 Radioactive Material Utilization

In order to maintain compliance with applicable regulations, the Texas Tech University Health Sciences Center (TTUHSC) Radioactive Material License, and to ensure the protection of all personnel, the following guidelines shall be incorporated into the radiation safety program of each Sublicensee:

(a) Appropriate radiation caution/warning signs and/or symbols shall be posted in all areas where radioactive material is used or stored.

(b) Radioactive material shall be stored in a locked room, cabinet, or refrigerator/freezer.

(c) TTUHSC personnel shall wear personal radiation exposure monitoring devices when entering or working in radiation use areas, radiation areas, high radiation areas, as required by applicable regulations, and pursuant to the guidelines outlined in this manual. Radiation Safety Services (RSS) shall maintain exposure monitoring results as required by applicable regulations.

(d) Radiation detection instruments shall be used, when appropriate, in radioactive material use areas. The instrument shall be capable of detecting the type of radiation in use at the time.

(e) Radiation survey instruments used for general radiation surveys shall be calibrated at intervals not to exceed 12 months. Each instrument shall be calibrated to read within +/- 20% of the correct exposure reading. Calibrations shall be performed by RSS, and/or individuals or companies authorized by Texas Department of State Health Services, Radiation Control (TDSHS-RC).

(f) Radiation use/work areas shall be monitored, as necessary, following the use of radioactive material to determine the presence of radioactive contamination.

(1) Radiation field levels should be determined using a radioactive survey instrument capable of detecting the type of radiation used.

(2) Radioactive contamination wipe tests shall be analyzed using an instrument capable of detecting the radiation in question. The counting efficiency of the instrument should be known to allow conversion of counts per minute (cpm) to disintegrations per minute (dpm).

(3) Decontamination limits are as follows:

(A) Contamination levels ≥ 1000 dpm beta/gamma activity per 100 cm^2 surface area shall be decontaminated to a level ≤ 200 dpm per 100 cm^2.

(B) Contamination levels > 200 dpm per 100 cm^2 and < 1000 dpm per 100 cm^2 may not be released for unrestricted use, however, do not require immediate decontamination action if contained in the identified radiation use/work area.

(C) Contamination levels ≤ 200 dpm per 100 cm^2 may be released to unrestricted use.

(4) RSS shall be notified when decontamination is required.

(5) Results of all radioactive decontamination surveys shall be maintained in the radiation safety files of the Sublicensee.

(g) Radiation survey instruments shall be checked periodically to ensure proper operation.

(h) Minor spills shall be cleaned up immediately. If a major spill occurs do not attempt decontamination. Contain the spill, if possible to safely do so, and isolate the area. Notify RSS as soon as possible in all instances.

(i) Personal Protection

(1) Protective clothing and radiation workers' hands should be monitored with appropriate survey equipment following completion of laboratory work involving the handling or use of unsealed radioactive material.

(2) Drinking, eating, application of cosmetics, and smoking is prohibited in all areas designated for use or storage of radioactive material. The rooms shall be posted accordingly.

(3) Employees shall wash hands thoroughly before drinking, eating, applying cosmetics, or smoking, and before leaving an area designated for the use of radioactive material.

(4) Mouth pipeting of liquid radioactive material or liquids containing radioactive material is forbidden.

(5) Minimum personal protective equipment worn in all radioactive material use/work areas shall include the following:

(A) Lab coat;

(B) Personal dosimetry device(s);

(C) Protective gloves appropriate for the chemicals/compounds being used;

(6) Additional personal protective equipment, such as long-handled tongs, gloves, smocks, shoe covers, and other appropriate equipment shall be used when such safety measures are considered necessary. Contact RSS for questions concerning the use of special protective equipment.

(7) Employees working with unsealed radioactive material shall wear lab coats, protective gloves, and personal dosimetry devices.

(8) Radioactive material and/or radioactive sealed sources shall not be handled with bare, unprotected hands.

(9) Radioactive sealed sources shall not be opened for any reason.

(j) Control of access and egress in restricted areas is the responsibility of the Sublicensee.

(k) Unsealed radioactive sources or liquids shall be stored in unbreakable, leak-proof containers. Secondary containment shall be used when practical.

(l) Work involving liquid radioactive material shall be performed on trays lined with absorbent paper, on surfaces protected with plastic-backed absorbent paper, or on non-porous work surfaces designed to contain liquids.

(m) Radioactive material shall not be used in or on human beings.

(n) Chemical hoods in which radioactive materials are used shall have a minimum air face velocity of 100 linear feet per minute.

(o) Glassware and equipment used with or containing radioactive material shall be properly labeled.

(p) Trial runs should be made, when practical, to determine proper procedures and to evaluate necessary radiation protection.

(q) Only designated sinks shall be used for washing radiation-contaminated glassware and lab ware.

(r) Only designated storage containers, freezers, and refrigerators shall be used for storage of radioactive material. Storage of food or drink in any freezer or refrigerator designated for storage of radioactive material is forbidden.

(s) Radioactive material storage containers shall be labeled in accordance with applicable regulations.

(t) All radioactive waste and contaminated material shall be placed in receptacles identified and labeled for this purpose.

(u) Suspected or known overexposures to any radiation worker or member of the general public shall be immediately reported to the RSO. The employee and Sublicensee shall prepare a written report, detailing circumstances of the overexposure, and any recommendations/measures taken to avoid similar events.

(v) Radioactive material producing a radiation dose rate in excess of 2 mR/hr at a distance of one foot from the source shall be stored in a shielded container sufficient to reduce the radiation dose rate to 2 mR/hr or less at one foot. Radiation dose rates that could result in a personnel exposure in excess of 100 mR in seven consecutive days, or 2 mR/hr, are forbidden in unrestricted areas. Radiation areas shall be posted as required by applicable regulations.

(w) RSS shall maintain records of radiation exposures of individuals required to wear personnel monitoring devices. Reports of exposures shall be sent to individuals pursuant to applicable regulations.

(x) Safety glasses, optical glasses, or goggles shall be worn while working with activity levels of ^{32}P greater than one millicurie (1 mCi) at any one time.

(y) Proposed changes to the original Radioactive Material Sublicense (laboratory space, isotopes, activities, radiation workers, etc.) shall be submitted to the Radiation Safety Committee (RSC) on RSS Form A-04, "Radioactive Material Sublicense Amendment/Renewal Request" form.

(z) RSO approval must be obtained prior to transfer of any radioactive material.

(aa) Copies of BRC Form 232-1, "NOTICE TO EMPLOYEES" shall be posted in a sufficient number of places in every authorized radioactive material use area so that employees entering the area can see the sign.

(bb) Emergency guidelines, names and telephone numbers of persons to be contacted in the event of an emergency shall be posted in radioactive material laboratory use and/or storage areas.

(cc) Each employee using radiation-producing equipment or radioactive material should be familiar with the regulations of the TTUHSC *Radiation Safety Manual* and applicable regulations. Copies of these documents are available upon request from RSS.

(dd) Additions and alterations to the rules contained in this manual may be made by the RSC, with approval of TDSHS-RC, when in the estimation of the RSC, such

additions and alterations are necessary for the protection of TTUHSC, its employees, and the general public.

2.3 Application for Radioactive Material Sublicense

Individuals seeking authorization to possess and use radioactive material within TTUHSC, including Regional Campuses, shall submit an application for a Radioactive Material Sublicense using RSS Form A-03, "Application for Radioactive Material Sublicense (Non-Human Use)" to the RSO. The RSO shall review and evaluate the applicant's qualifications, laboratory procedures, and protocol for radiation safety. Upon completion of the RSO review, the application will be submitted to the RSC for review and approval.

(a) Information to be included on the application shall include, but not be limited to the following:

(1) Radioactive material to be used;

(2) Physical and chemical form of the radioactive material;

(3) Maximum activities of radioactive material required on inventory;

(4) Total activities of radioactive material to be used at any one time;

(5) Scope of use, including frequency of radioactive material use, types of procedures and protocols, with emphasis on potential for release of radioactive material;

(6) Labeled diagrams for each use or storage laboratory/room/area, indicating expected traffic patterns, radioactive material storage areas, radiation hoods/cabinets, radiation sinks, radiation refrigerators/freezers, radiation waste storage areas, etc.;

(7) Listing of anticipated authorized radiation workers;

(8) Identification of the individual responsible for proper use of radioactive material;

(9) Documentation of training of the individual(s) listed in (7) and (8);

(10) Radiation safety measures planned to ensure that employees, students, or the general public are not exposed to excessive radiation;

(11) Detection and monitoring equipment, both fixed and portable;

(12) Radiation survey and/or wipe survey procedures;

(13) Ability of user (or staff) to perform routine radiation surveys effectively and within a specified frequency;

(14) Security provisions and location of regulatory and emergency information postings;

(15) Emergency procedures to be taken in the event of an incident; and

(16) Guidelines for handling animals, animal waste, and animal carcasses, if applicable.

(b) Application information to be reviewed by the RSO and RSC shall include, but not be limited to the following:

(1) Appropriate training and experience of any new user not currently authorized;

(2) Identification of users and supervised staff and/or assistants to work under this sublicense;

(3) Documentation of radiation safety training for all individuals designated as authorized users or radiation workers;

(4) Determination of the need for appropriate personnel dosimetry monitoring and/or bioassay programs;

(5) Determination of the frequency of surface contamination surveys to be performed by the primary user;

(6) Determination of inspection frequency by the RSO and/or RSS;

(7) Availability of primary users to provide adequate and frequent supervision of subordinate staff.

2.4 Absence of Sublicensee

Any individual possessing a Radioactive Material Sublicense who expects to be absent from the campus for a period of time greater than three (3) weeks, shall observe the following requirements:

(a) Suspend or terminate the utilization of radioactive material currently possessed; or

(b) Notify RSS of the individual (must be another Radioactive Material Sublicensee competent in the use of the particular radioactive material) responsible for the supervision of use of the radioactive material in the absence of the Sublicense; or

(c) The Chair of the RSC may, with Committee agreement, assume the responsibility of the absent Sublicensee; or

(d) Should a Sublicensee leave the campus to work at another institution, the radioactive material may be transferred to that institution, pending notification of approval by the Radiation Safety offices of both institutions; or

(e) The radioactive material may be transferred to another Sublicensee, pending approval of the RSC; or

(f) RSS may place the radioactive material in storage, pending disposal in accordance with applicable regulations.

2.5 Sublicense Amendment

A Radioactive Material Sublicense may be amended by completing the following requirements:

(a) Complete RSS Form A-04 "Radioactive Material Sublicense Amendment/Renewal Request" and forward the form, accompanied by a copy of the current sublicense, to RSS;

(b) RSS will review the amendment request for accuracy and completeness and submit it to the RSC for approval;

(c) Upon approval, a new Radioactive Material Sublicense will be issued with written notification of the amendment approval and changes made.

2.6 Sublicense Renewal

The TTUHSC Radioactive Material Sublicense remains in effect for a period of two years from the last day of the month in which the Sublicense was originally issued. RSS will usually remind Sublicensees of renewal prior to the expiration of the Sublicense; however, it is the responsibility of the Sublicensee to submit a renewal application in a timely manner. Following is the process for renewal of a Radioactive Material Sublicense:

(a) RSS will notify each Sublicensee of the impending expiration of the Sublicense, by mail, approximately six (6) weeks prior to expiration. Notification shall include the following:

(1) A request that the sublicensee submit a completed RSS Form A-04 "Radioactive Material Sublicense Amendment/Renewal Request" at least two (2) weeks prior to the RSC meeting held in the month of expiration;

(2) A copy of RSS Form A-04 "Radioactive Material Sublicense Amendment/Renewal Request;" and

(3) Notification that failure to renew the Radioactive Material Sublicense will result in suspension of the Sublicense for a period of thirty (30) days, following expiration.

(b) In the event that the Sublicensee has not returned the completed renewal form to RSS by the specified date, RSS will make another notification no later than two (2) weeks prior to the RSC meeting, requesting immediate action on the part of the Sublicensee.

(c) In the event that the Sublicensee fails to submit the completed renewal form by the date of the RSC meeting, the RSC will suspend the sublicense for a period of thirty (30) days from the date of expiration, or until the next regularly scheduled meeting of the RSC. During the period of suspension, RSS will confiscate all radioactive material and no further work with radioactive material will be permitted in the radiation work areas of the Sublicensee.

(d) If necessary, additional attempts to contact the Sublicensee regarding the renewal or termination of the Sublicense will be made by the RSO. If the Sublicensee submits the completed renewal form prior to the next meeting of the RSC, the suspension may be removed, and all radioactive material will be returned to the Sublicensee. If, however, the Sublicensee cannot be contacted or does not submit a renewal form within the prescribed time limit, the RSC will terminate the Sublicense at

the next regularly scheduled Committee meeting, and the Sublicensee shall be required to complete a new application for a Radioactive Material Sublicense.

2.7 Inactive Radiation Laboratory and Use Areas

Should a Sublicensee foresee a period of time in which all or a portion of the radiation use areas under the Sublicense will not be using radioactive material, the area may be classified as an inactive area, while maintaining an active Radioactive Material Sublicense. The following guidelines should be observed when requesting that a radiation use area be reclassified as inactive:

(a) A letter requesting the reclassification of an authorized radiation use area to inactive status shall be submitted to the RSO. The letter shall include the following information:

(1) The room number and a labeled diagram of the proposed inactive laboratory(s)/work areas;

(2) A statement indicating that all radioactive material used and/or stored in the area will be removed, either by transfer to RSS for storage and/or disposal, or by transfer to another Sublicensee authorized to possess the radioactive material and activity levels, without exceeding the possession limits of that Sublicensee;

(3) A statement indicating that the Sublicensee will perform a close-out radiation contamination wipe survey consisting of a minimum of thirty (30) to forty (40) wipes in the proposed inactive area(s), and certification that all areas will be decontaminated to an activity level of < 100 dpm per 100 cm^2.

(b) Upon receipt of the letter of intent, the RSO will perform an independent radiation contamination close-out wipe survey of the affected area(s).

(c) Based on review of the letter of intent, the results of the close-out survey(s), and the disposition of the radioactive material, the RSO will make a recommendation to the Chair of the RSC, to authorize reclassification of the area(s) to inactive status.

(d) Upon approval of inactive status, all radiation signs, labels, and markings shall be removed from the area.

(e) The area is released for unrestricted use, and possession or use of radioactive material in this area is forbidden.

(f) Inactive status should only be considered for periods of time greater than three (3) months.

(g) In the event that the Radioactive Material Sublicense should come due for renewal, and the Sublicensee desires to maintain an inactive status, a memorandum indicating this should accompany the request for Sublicense renewal.

(h) During the period in which a radiation use area is classified as inactive, the Sublicense will remain in active status.

(i) If all radiation laboratories or work areas listed on the Sublicense are classified as inactive, the Sublicense will require only minimal maintenance, i.e., periodic renewal and changes in radiation worker status. Inactive laboratory or work areas are no longer considered radiation use areas, and the requirement for monthly radiation contamination surveys no longer applies.

(j) If active radiation laboratory or work areas remain on the Sublicense, all applicable rules, regulations, policies, and procedures remain in effect for those areas.

(k) The Sublicensee shall be responsible for retention of all records and files for the inactive area(s) generated while the area(s) was an active radiation use area.

2.8 Activation of Inactive Areas

A Sublicensee may reactivate an inactive laboratory or work area by observing the following procedures:

(a) A written request to reactivate an inactive laboratory or work area must be submitted to the RSO. The request should include a labeled diagram of the laboratory/work area indicating radiation use areas, storage areas, waste container locations, radiation sinks, etc. The laboratory or work area will be reactivated only under the initial conditions and configuration at the time of classification to inactive status.

(b) The RSO will review the reactivation request, inspect the laboratory/work area(s), and make a recommendation to reactivate the area(s) to the Chair of the RSC.

(c) Upon approval by the Chair of the RSC, the area(s) will be reactivated, and will be subject to applicable rules, regulations, policies, and procedures for a radiation use area. Required signs, labels, and markings shall be applied, as appropriate, and all other required postings, notices, records, procedures, and survey requirements shall be reactivated.

(d) Upon completion of the reactivation process, radioactive material may be used and stored in the area(s).

2.9 Termination of Radioactive Material Sublicense

The following procedure shall be used by a Sublicensee to terminate a Radioactive Material Sublicense:

(a) A letter of intent to terminate the Radioactive Material Sublicense shall be submitted to the RSO. The letter shall include the following:

(1) The date on which termination is desired;

(2) A list of the Sublicensee's authorized radiation use laboratories, work areas, and storage areas;

(3) A labeled diagram of the radiation use laboratories, work areas, and storage areas;

(4) A statement that all radioactive material used and/or stored in the authorized area(s) will be removed by either transfer to RSS for storage and/or disposal, or by transfer to another Sublicensee authorized to possess the radioactive material and activity levels, without exceeding the possession limits of that Sublicensee; and

(5) The terminating sublicensee shall provide copies of the results of a close-out radiation contamination wipe survey consisting of a minimum of thirty (30) to forty (40) wipes in each of the radiation use area(s), and certification that all areas have been decontaminated to an activity level of < 100 dpm per 100 cm^2.

(b) Upon receipt of the letter of intent, the RSO will perform an independent radiation contamination close-out wipe survey of the affected area(s).

(c) Based on the RSO review of the letter of intent, the results of the close-out surveys and the disposition of the radioactive material inventory, the RSO will make recommendations to terminate the Sublicense at the next regularly scheduled meeting of the RSC. The RSC will consider the request and vote on approval to terminate the Sublicense.

(d) Upon termination of the Sublicense, all signs, labels, and markings indicating the use of radioactive material shall be removed.

(e) Upon completion of the above requirements, the area(s) is released for unrestricted use, and possession or use of radioactive material in this area is forbidden.

(f) Should a Sublicensee leave TTUHSC and neglect to officially terminate the Radioactive Material Sublicense, the RSO shall contact the Chair of the department in which the area is located. The department Chair shall be informed of the responsibility for initiating the termination procedures as outlined above.

2.10 Reporting of Incidents

It is the responsibility of the Sublicensee to report all accidents/incidents involving radioactive material to RSS as soon as possible. The Sublicensee shall prepare a written report of the incident within one (1) working day, using RSS Form A-07 "Report of Incidents Involving Radioactive Material." The report shall be delivered to RSS as soon as possible upon completion.

2.11 X-Ray-Producing Devices

Only qualified personnel shall be allowed to operate any x-ray-producing devices, including x-ray machines, electron microscopes, and irradiators. A dosimetry-monitoring device shall be worn by the operator of these devices, as required by applicable regulations.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Section 3 Radioactive Material Accountability

3.1 General

No person within Texas Tech University Health Sciences Center (TTUHSC), including regional campuses, shall receive, possess, use, transfer, own, or acquire radioactive material except as authorized by a TTUHSC Radioactive Material Sublicense. Authorized users (Sublicensees) shall have completed RSS Form A-03, "Application for Radioactive Material Sublicense (Non-Human Use)" and submitted this form to the RSO. The RSO shall review and evaluate the prospective radioactive material user's qualifications, training, experience, and plans for radiation safety, and upon completion of the review, shall submit the application to the Radiation Safety Committee for review and approval. Radioactive material may not be received, possessed, used, transferred, owned, or acquired prior to approval of the application and receipt of the Radioactive Material Sublicense.

3.2 Ordering of Radioactive Material

(a) Authorized users may request on-line order approval for radioactive material by observing the following steps:

(1) Access the TTUHSC Safety Services web page at http://www.ttuhsc.edu/admin/safety.

(2) Click on "Materials Ordering";

(3) Click on the radiation warning symbol or "Proceed with Rad order";

(4) Click on the "Choose an Isotope" drop down menu arrow and select the appropriate radioactive isotope;

(5) Enter the chemical form of the material;

(6) Enter the activity to be ordered (in μCi);

(7) Enter the vendor name;

(8) Enter the cost of the order;

(9) Enter the departmental reference or P.O. number;

(10) Click on the "Name of Sublicensee" drop down menu arrow and select the appropriate Sublicensee;

(11) Click on the "Choose the department of the Sublicensee" drop down menu arrow and select the appropriate department;

(12) Enter the Room/Laboratory number for delivery;

(13) Enter the account number to which the order will be billed;

(14) Enter the name of the individual placing the order;

(15) Enter the telephone number of the individual placing the order;

(16) Enter the anticipated delivery date; and

(17) Enter the e-mail address of the individual placing the order for order confirmation response.

(b) Authorized users may request order approval for radioactive material by telephoning Radiation Safety Services at (806) 743-2597 and having the following information available:

(1) The name of the individual placing the order;

(2) Department of the individual placing the order;

(3) Telephone number of the individual placing the order;

(4) The name of the Sublicensee;

(5) The name of the vendor;

(6) Radioactive isotope to be ordered;

(7) The activity being ordered (in μCi);

(8) The chemical form of the material;

(9) The cost of the purchase;

(10) The account number being charged; and

(11) The anticipated delivery date of the shipment.

(c) In each case, the order approval request will be verified by RSS to ensure that the Sublicensee is authorized to possess the requested radioactive material, and that the authorized activity limit for that isotope will not be exceeded by the order.

(d) Orders exceeding a cost of $1,000.00 may require a purchase order. Verify departmental or institutional policy prior to requesting order approval.

(e) Upon approval by RSS and any departmental approvals, the order may be placed with the vendor.

(f) All shipments must include an attention line on the shipping address to include the following:

(1) TTUHSC – Lubbock, "Attention: Radiation Safety Officer"; or

(2) TTUHSC – Regional Campus, "Attention: Radiation Safety Coordinator".

(g) Deviation from the above purchase approval procedures may delay processing of the request.

(h) Radioactive material purchased without prior approval and confirmation by RSS is a violation of the conditions of the Radioactive Material License, and may lead to disciplinary action, up to and including suspension of the Radioactive Material Sublicense and confiscation of all radioactive material.

3.3 Shipping of Radioactive Material

Shipments of radioactive material to institutions outside of TTUHSC shall meet and comply with the requirements of applicable regulations. Contact RSS for information regarding shipment of radioactive material.

3.4 Receipt of Radioactive Material

(a) All incoming shipments of radioactive material shall be delivered to the TTUHSC Shipping and Receiving Department at each active campus.

(b) RSS shall be notified of incoming packages of radioactive material as soon as possible. An RSS representative will pick up the package(s) from receiving personnel and perform the following check-in procedures:

(1) Inspect all radioactive material packages for external damage.

(2) Measure the external surface radiation levels of the package. External surface radiation levels of the package will not exceed 200 millirem per hour (mrem/hr) [2 millisievert per hour (mSv/hr)] at any time during transportation. The transport index shall not exceed 10.

(3) Perform an external contamination wipe survey on the exterior of each package. The level of removable radioactive surface contamination shall be ALARA. Removable external radioactive contamination wipe limits will not exceed the levels in the following table:

Contaminant	Maximum Permissible Limits	
	$\mu Ci/cm^2$*	dpm/cm^2
Beta-gamma emitting radionuclides; all radionuclides with half-lives less than 10 days	10^{-5}	22
All other alpha emitting radionuclides	10^{-6}	2.2

* To convert microcuries (μCi) to SI units of kilobecquerels (kBq), multiply the values by 37.

Removable contamination found in excess of the levels listed in the above table may require notification as required by applicable regulations. An incident investigation shall be conducted to determine the extent of radioactive contamination, if any, and decontamination procedures initiated. A written report of the incident shall be prepared upon completion of the investigation and decontamination.

(4) Initiate the accountability tracking system for each package.

(5) Open each package and conduct an internal contamination wipe survey. The level of internal radioactive contamination shall be ALARA. Evidence of internal leakage or contamination shall be documented and protective measures taken to prevent further leakage and contamination.

(6) An RSS Form A-05, "Radioactive Material Receipt and Accountability Record" will be completed and delivered to the Sublicensee with the radioactive material package(s). If the radioactive material package is to be picked up by the Sublicensee, RSS will inform the Sublicensee of the arrival of the package and schedule a convenient time for the package to be picked up.

(7) Upon receipt of the radioactive material and accompanying records, the Sublicensee will verify the shipment is as ordered and will acknowledge receipt by signing the accompanying records. RSS will retain the top (green) copy of the record, and the Sublicensee will maintain the remaining copies.

3.5 Storage, Posting, and Security

(a) Radioactive material stored in a cabinet, refrigerator, freezer, or other approved location must be sufficiently shielded so that radiation levels at the surface of the storage area remains below 2 mR/hr.

(b) Radiation warning signs shall be posted as required by applicable regulations.

(c) Radioactive material storage areas shall provide adequate security as required by applicable regulations.

3.6 Transfer of Radioactive Material

(a) Radioactive material shall not be transferred from one Sublicensee to another without approval of the RSO.

(b) The transferring Sublicensee will complete the original "Radioactive Material Receipt and Accountability Record" form for the radioactive material to be transferred, and a new record will be prepared by RSS and will be delivered to the receiving Sublicensee.

(c) Radioactive material transferred to institutions outside of TTUHSC shall be transferred only to an organization authorized to possess the particular radioactive isotope and activity. A copy of the Radioactive Material License of the recipient shall be obtained prior to transfer.

3.7 Additional Information

Questions concerning rules and regulations regarding the purchase, shipping, receipt, storage, posting of radiation warnings, or transfer of radioactive material should be directed to RSS.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Section 4 Instrumentation

4.1 General

Various types of radiation detection and survey instruments and equipment are possessed and used by Radiation Safety Services and the various research laboratories within TTUHSC. The primary use of these instruments is for routine monitoring and to provide additional monitoring in the event of a radiation emergency.

4.2 Instrument List

(a) Beckman-Coulter

(1) Model LS6500 Scintillation Counting System

(b) Bicron

(1) Model 50 Survey Meter with GM probe (Pancake)

(c) Canberra

(1) Series 20 Multi-Channel Analyzer with the following probes:

(A) Bicron Scintillation Well Counter

(B) Ludlum Scintillation Probe Model 44-3

(C) Ludlum Scintillation Probe Model 44-10

(d) Eberline

(1) Model E-120 Survey Meter with end-window GM probe

(e) Johnson, William B.

(1) Model GSM-5 Survey Meter (0-50k cpm) with the following probes:

(A) Johnson beta-gamma GM Probe (End Window)

(B) Johnson beta-gamma GM Probe (Side Window)

(C) Johnson beta-gamma GM Probe (Pancake)

(2) Model GSM-10 Survey Meter with the following probes:

(A) Johnson beta-gamma GM Probe (End Window)

(B) Johnson beta-gamma GM Probe (Side Window)

(C) Johnson beta-gamma GM Probe (Pancake)

(3) Model GSM-110 Survey Meter with the following probes:

(A) Johnson beta-gamma GM Probe (End Window)

(B) Johnson beta-gamma GM Probe (Side Window)

(C) Johnson beta-gamma GM Probe (Pancake)

(f) Landauer

(1) OSL dosimeter devices for beta, gamma, x-ray exposure monitoring

(2) TLD dosimeter devices for beta, gamma, x-ray exposure monitoring

(g) Ludlum Measurements

(1) Model 2 Survey Meter with the following probes:

(A) Ludlum Scintillation Probe Model 44-3

(B) Ludlum beta-gamma GM Probe Model 44-7 (End Window)

(C) Ludlum beta-gamma GM Probe Model 44-9 (Pancake)

(2) Model 3 Survey Meter (0-500K cpm) with the following probes:

(A) Ludlum Scintillation Probe Model 44-3

(B) Ludlum beta-gamma GM Probe Model 44-7 (End Window)

(C) Ludlum beta-gamma GM Probe Model 44-9 (Pancake)

(3) Model 3A Survey Meter (0-500K cpm) with the following probes:

(A) Ludlum Scintillation Probe Model 44-3

(B) Ludlum beta-gamma GM Probe Model 44-7 (End Window)

(C) Ludlum beta-gamma GM Probe Model 44-9 (Pancake)

(4) Model 3-98 Survey Meter with internal GM detector and Ludlum Scintillation Probe Model 44-3

(5) Model 17 beta-gamma Ion Chamber Survey Meter (0-50k mR/hr)

(6) Model 18 Survey Meter (0-500k cpm) with the following probes:

(A) Ludlum Scintillation Probe Model 44-3

(B) Ludlum Scintillation Probe Model 44-10

(7) Model 177 Alarm Survey Meter (0-500k cpm) with Ludlum beta-gamma GM Probe Model 44-9 (Pancake)

(8) Model 500 Pulser (instrument calibration)

(9) Model 500-2 Pulser (instrument calibration)

(h) Microtec Services

(1) Model 900 Survey Meter

(i) Mini-Instrument

(1) Model 5-10E Survey Meter with end-window GM probe

(j) Nuclear Chicago

(1) Model C-2550 Survey Meter

(k) Radalert

(1) Model 50 Survey Meter with internal GM detector

(l) Radcal

(1) Model MDH 2025 AC Survey Meter (0.1 mR - 1.0 R/hr and 1.0 uR - 20,000 R integrated) with the following probes:

(A) 20X5-3 ion chamber

(B) 20X5-180 ion chamber

(m) RPI (Research Products International)

(1) Rad-Monitor GM-2 Survey Meter with end-window GM probe

(n) RTI

(1) PMX-III R/M Multimeter

(o) TM Analytical

(1) Model 5303 Mark V Scintillation Counting System (Efficiency 65% ^{3}H)

(p) Victoreen

(1) Model 471RF Survey Meter with beta-gamma ion chamber (0-300 R/hr)

(2) Model 470A Survey Meter with beta-gamma ion chamber (0-1000 R/hr)

(3) Model 450P µR Survey Meter with beta-gamma ion chamber (0-5 R/hr)

(4) Model 493-5 Survey Meter with Model 491-40 probe

(5) Model 2000A Pocket Dosimeter

4.3 Instrument Calibration

(a) Radiation survey instruments shall be calibrated at intervals not to exceed twelve (12) months. Calibration shall be at an accuracy within 20%of the true radiation level. Calibrations shall be made using an appropriate radiation source, dependent on the type of radiation the instrument is designed to detect. The Radiation Safety Officer (RSO), appropriately trained Radiation Safety Specialists, or an approved, licensed calibration vendor shall perform instrument calibrations.

(b) Radiation detection instruments reading in milliroentgen or roentgen, shall be exposed to a known (calculated) radiation field. Radiation detection instruments reading in counts per minute or seconds shall be calibrated using a Ludlum 500 Pulse Generator. The instrument shall be adjusted to an accuracy within 20%of the

true value. At least two radiation exposure values shall be checked for each meter scale; preferably, these values should be approximately 30%and 70% of the full-scale reading.

(c) Upon completion of instrument calibration, either by the pulser method or on the calibration range, all associated probes shall be directly exposed to a radiation reference source that emits the same type of radiation of similar energy that corresponds to the radioisotopes that the meter is to detect in the laboratory.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Section 5
Tests and Records

5.1 General

Texas Department of State Health Services, Radiation Control (TDSHS-RC) regulations require that certain tests be made and records of the results of these tests be maintained and retained for specific periods of time. Requirements for radiation surveys and records of these surveys are contained in 25 Texas Administrative Code (TAC) §289.201 and §289.202. Requirements for personnel monitoring are found in 25 TAC §289.201, §289.202, and §289.203. Posting requirements are described in 25 TAC §289.202 and §289.203. Requirements for storage of sources of radiation are found in 25 TAC §289.202. The requirements for waste disposal are contained in 25 TAC §289.202. Conditions of the Radioactive Material License may also contain additional requirements. Each professional employee authorized to possess, use, or store radioactive material or radiation-producing machines, shall become familiar with the applicable regulations and shall ensure that those individuals working under their supervision are also familiar with applicable regulations.

5.2 Inspections

(a) Periodic Inspections

(1) The Radiation Safety Officer (RSO) or designated alternate shall make periodic inspections of the areas of radioactive material use and storage.

(2) Periodic inspections shall also include inspection of records of accountability, utilization, waste disposal, and surveys, as required to be maintained by the Sublicensee in the radioactive material use area.

(3) Periodic inspections shall be used to determine compliance with TTUHSC policy and procedure and applicable regulations.

(b) Contamination Surveys

(1) Laboratories and facilities where radioactive materials are used or stored shall be surveyed periodically to detect any changes in radiation levels to prevent the spread of radioactive contamination.

(2) The frequency of contamination surveys shall be determined by the RSO, based on the activity and radioactive isotope in use (see Table 5-1).

Table 5-1
Frequency of Contamination Surveys

Description	Frequency	Explanation
Low-level areas	Not less than once per month	Areas in which in vitro tests are performed, samples analyzed, etc. (samples usually less than 100 microcuries each)
Medium-level areas	Not less than once per week	Areas in which millicurie amounts of radioactive material are handled (total weekly radioactive material use exceeds 5.0 millicuries)
High-level areas	Not less than once per day	Areas used for storage of active solutions, preparation of materials, fume hoods, etc. (usually curie amounts)

(3) Records of these surveys shall be maintained in the Radiation Safety files of the Sublicensee.

5.3 Radioactive Waste Disposal

The "Radioactive Waste Disposal Record" (RSS Form A-06) shall be used for recording all waste disposals. Duplicates of the form shall be maintained in the Radiation Safety file of each Sublicensee, and Radiation Safety Services (RSS) shall maintain the original documents. The form shall include identification of the radioactive isotope, the activity in millicuries, the type of waste (solid, liquid, liquid scintillation vials, animal carcass, etc.), and the date of disposal.

5.4 Inventory

A computer-based and manual inventory for each authorized Sublicensee shall be maintained by RSS. Radioactive material will be identified and tracked by the shipment number generated at the time of receipt by RSS. Inventory verification sheets shall be sent to Sublicensees periodically, for verification of inventory accuracy.

5.5 Personnel Dosimetry and Analyses

(a) Personnel Dosimetry

(1) A centralized personnel exposure monitoring service is available for all authorized users of radioactive material or radiation-producing equipment at TTUHSC.

(2) Personnel dosimetry services are contracted through a vendor licensed or registered by TDSHS-RC and accredited by the National Voluntary Laboratory Accreditation Program (NVALP) of the National Institute of Standards and Technology.

(3) Requests for radiation dosimetry services shall be initiated by completing the "Application for Personal Dosimetry Service" (RSS Form A-08) form, and returning the completed form to RSS. RSS will then obtain the appropriate monitoring device from the dosimetry vendor.

(4) Personal radiation exposure dosimeters shall be worn by TTUHSC personnel under the following conditions:

(A) When entering any radioactive material use/work areas;

(B) Adults likely to receive, in one year from sources external to the body, a dose in excess of 10% of the annual regulatory limits;

(C) Minors likely to receive, in one year from sources of radiation external to the body, a deep dose equivalent in excess of 0.1 rem (1 millisievert (mSv)), a lens dose equivalent in excess of 0.15 rem (1.5 mSv), or a shallow dose equivalent to the skin or to the extremities in excess of 0.5 rem (5 mSv);

(D) Declared pregnant women likely to receive during the entire pregnancy, from sources of radiation external to the body, a deep dose equivalent in excess of 0.1 rem (1 mSv);

(E) Individuals entering a high or very high radiation area;

(F) Any person working with millicurie activities of a beta emitter with energies greater than 500 keV;

(G) Any person working with activities greater than 5 millicuries of a gamma emitter with energies less than 100 keV; or

(H) Any person working with millicurie activities of a gamma emitter with energies greater than 100 keV.

(5) Dosimetry files for TTUHSC personnel shall be maintained by RSS.

(b) Bioassay Program

(1) Radioactive Iodine – ^{125}I and ^{131}I

(A) General

(i) Solutions of radioactive iodine may be volatile, thus resulting in the potential uptake of radioactive iodine by individuals working with these materials. Inside the body, iodine concentrates in the thyroid, contributing to the radiation dose received by that organ. The radioactive iodine bioassay program will enable RSS staff to determine individual radioactive iodine thyroid burden, from which the thyroid organ dose can be determined for those individuals who have had an uptake. In addition, the program will monitor the effectiveness of radioactive material handling procedures.

(ii) The radioactive iodine bioassay program is designed to meet applicable regulations for bioassay of ^{125}I and ^{131}I.

(iii) Activity levels of radioactive iodine requiring bioassay are contained in Table 5-2.

Table 5-2
Activity Levels for ^{125}I and ^{131}I Requiring Bioassay

Type of Operation	Activity Handled/Used in Uncontained Form	
	Volatile or Dispersible	Non-Volatile or Dispersible
Process in open room or bench with possible escape of iodine from process vessels	0.1 mCi	1.0 mCi
Process carried out within a fume hood of adequate design, face velocity, and performance reliability, with possible escape of iodine	1.0 mCi	10 mCi
Process carried out in glove box, normally closed, with possible release of iodine from process, occasional exposure to contaminated box, and possible box leakage	10 mCi	100 mCi

(iv) Operations involving the routine use of ^{125}I or ^{131}I in an open room or bench is discouraged. Whenever practical, sealed bottles or containers holding more than 0.1 mCi of ^{125}I or ^{131}I should be opened, at least initially, within an operational fume hood.

(B) Bioassay Program Participation

(i) Individuals who handle or use unsealed activities of ^{125}I and/or ^{131}I in excess of the activities listed in Table 5-2, and those individuals working close enough to such handling that uptake is possible (working within a few yards) must also participate in the bioassay program. The activities listed in Table 5-2 apply to that amount handled either in a single usage or the total amount handled over a period of three (3) consecutive months.

(ii) It shall be the responsibility of the individual authorized users to notify RSS of the names of those individuals working under their supervision who require bioassay for radioactive iodine.

(C) Frequency of Bioassay

(i) Prior to beginning work with ^{125}I or ^{131}I in quantities that require participation in the bioassay program, individuals should be given a "baseline" bioassay.

(ii) Following commencement of work with activities of radioactive iodine necessitating participation in the bioassay program, a "routine" bioassay shall be performed within 72 hours (but not less than 6 hours) on those individuals. Bioassays shall continue on a biweekly schedule as long as utilization conditions exist which necessitate that an individual participates in the bioassay program.

(iii) When work with radioactive iodine occurs at intervals greater than two (2) weeks, a bioassay shall be performed within 10 days of the end of radioactive iodine operations. Individuals working under conditions that present a high potential for uptake of radioactive iodine may be required to have bioassays more frequently than biweekly.

(iv) Following three (3) months of routine biweekly bioassays, the frequency of bioassays may be reduced to quarterly, at the discretion of the RSO, based on the results of the bioassays.

(v) An "emergency" bioassay shall be performed as soon as possible on any individual following an incident in which that individual may have received an uptake of ^{125}I in excess of 0.5 µCi or an uptake of ^{131}I in excess of 0.14 µCi.

(vi) Individuals required to participate in this program should undergo a "post-operational" bioassay within two (2) weeks of discontinuing operations with radioactive iodine. This bioassay should be performed prior to termination of employment or withdrawal from TTUHSC.

(D) Action Levels and Corresponding Actions

(i) When the thyroid burden at the time of measurement exceeds 0.12 µCi of ^{125}I or 0.04 µCi of ^{131}I, the following action should be taken:

(I) Investigation of isotope handling procedures. If this investigation indicates that a continuation of current operations would cause further uptake of radioactive iodine in excess of the above limits, operations shall cease until corrective actions can be taken;

(II) Restrict the affected individual from further work with radioactive iodine until the thyroid burden is less than the above limits;

(III) Perform bioassays on the affected individual at biweekly intervals until the thyroid burden is below the above limits;

(IV) Calculate the committed thyroid dose based on biological half-life determined from follow-up bioassays; and

(V) Make appropriate exposure record entries and notify the TDSHS-RC as required by applicable regulations.

(ii) In addition to the above actions, when the thyroid burden exceeds 0.5 µCi of ^{125}I or 0.14 µCi of ^{131}I, the following actions shall be taken:

(I) Refer the case to appropriate medical and health physics consultation; and

(II) Perform bioassays at weekly intervals until the thyroid burden is reduced to less than the allowable limits.

(iii) If the affected individual and others working in the same area were on a quarterly bioassay schedule at the time the allowable limits were

exceeded, the biweekly bioassay schedule shall be reinstated until it has been demonstrated that further exposures will not cause the limits to be exceeded.

(E) Bioassay Procedures

(i) Prior to commencement of operations using activities of ^{125}I or ^{131}I in excess of those listed in Table 5-2, Sublicensees shall notify RSS of these operations and provide the names of those individuals who meet the criteria for bioassay. Authorized users shall not permit any individual who meets these criteria to work with or near radioactive iodine until they have undergone a baseline bioassay.

(ii) RSS shall contact these individuals and schedule bioassays.

(iii) Individuals participating in this program shall notify RSS following their initial contact with radioactive iodine, to schedule the first routine bioassay (to be performed within 6-72 hours). Upon completion of this first bioassay, a bioassay schedule shall be established by RSS.

(iv) Any individual involved in a radiological incident who may have exceeded the allowable limits shall notify RSS immediately.

(v) Any individual who is participating in this program shall notify RSS prior to terminating employment or leaving TTUHSC.

(vi) Bioassays shall be performed by individuals designated by the RSO and shall be conducted in accordance with an accepted bioassay procedure.

(2) Tritium – ^{3}H

(A) General

(i) Tritium solutions may be volatile, thus resulting in the potential uptake by individuals working with these materials. The tritium bioassay program will enable RSS staff to determine individual tritium uptake, and will aid in monitoring the effectiveness of radioactive material handling procedures.

(ii) The tritium bioassay program is designed to meet applicable regulations for bioassay of tritium (^{3}H).

(iii) Individuals involved in operations that utilize, at any one time, more than 8 millicuries (mCi) of tritium in an uncontained form, other than

tritium foil, shall have bioassays performed within one week following a single operation and at weekly intervals for continuing operations.

(iv) Operations involving the routine use of activities of tritium greater than 8 mCi in an open room or bench is discouraged. When practical, activities involving the use of tritium should be performed within an operational fume hood.

(B) Bioassay Program Participation

(i) Individuals who handle or use unsealed activities of tritium in excess of 8 mCi, and those individuals working close enough to such handling that uptake is possible (working within a few yards) must also participate in the bioassay program. The 8 mCi activity applies to that amount handled either in a single usage or the total amount handled over a period of one (1) month.

(ii) Tritium bioassays should also be performed when an employee can come into skin contact with, ingest, or absorb into the body through cuts, abrasions, or accidental (hypodermic) injection, water or any other substance with concentrations of tritium greater than or equal to 0.01 mCi/kg (0.01µCi/cc) such as may be common in laboratory applications.

(iii) It shall be the responsibility of the individual authorized users to notify RSS of the names of those individuals working under their supervision who require bioassay for tritium uptake.

(C) Frequency of Bioassay

(i) Prior to beginning work with tritium in quantities that require participation in the bioassay program, individuals should be given a "baseline" bioassay.

(ii) Following commencement of work with activities of tritium necessitating participation in the bioassay program, a "routine" bioassay shall be performed within one (1) week on those individuals. Bioassays shall continue on a weekly schedule as long as utilization conditions exist which necessitate that an individual participates in the bioassay program.

(iii) Following three (3) months of routine weekly bioassays, the frequency of bioassays may be reduced to quarterly, at the discretion of the RSO, based on the results of the bioassays, provided that the average urinary tritium concentration obtained from the worker during the three-month period does not exceed 3 µCi/L and the working conditions during the three-month period with respect

to tritium exposure are representative of working conditions during the period in which a quarterly urinalysis frequency is employed.

(iv) An "emergency" bioassay shall be performed as soon as possible on any individual following an incident in which that individual may have received an uptake of tritium in excess of allowable concentrations.

(v) Individuals required to participate in this program should undergo a "post-operational" bioassay within one month of discontinuing operations with tritium. This bioassay should be performed prior to termination of employment or withdrawal from TTUHSC.

(D) Action Levels and Corresponding Actions

(i) When urinary excretion concentrations of tritium exceed 5 µCi/L, but are less than 50 µCi/L, the following action should be taken:

(I) Investigation of isotope handling procedures. If this investigation indicates that a continuation of current operations would cause further uptake of tritium in excess of the above limits, operations shall cease until corrective actions can be taken;

(II) Restrict the affected individual from further work with tritium until the urinary concentration of tritium is less than the above limits;

(III) Perform a repeat bioassay on the affected individual(s) within one week;

(IV) Calculate the committed internal dose based on biological half-life determined from follow-up bioassays; and

(V) Make appropriate exposure record entries and notify the TDSHS-RC as required by applicable regulations.

(ii) If urinary excretion concentrations exceed 50 µCi/L, the following actions shall be taken:

(I) Carry out all steps in *(i)*;

(II) Notify TDSHS-RC as required by applicable regulations;

(III) Refer the case to appropriate medical and health physics consultation; and

(IV) Perform bioassays at weekly intervals until the urinary excretion concentration is reduced to less than the allowable limits.

(E) Bioassay Procedures

(i) Prior to commencement of operations using activities of tritium in excess of 8 mCi, Sublicensees shall notify RSS of these operations and provide the names of those individuals who meet the criteria for bioassay. Authorized users shall not permit any individual who meets these criteria to work with or near tritium until they have undergone a baseline bioassay.

(ii) RSS shall contact these individuals and schedule bioassays.

(iii) Individuals participating in this program shall notify RSS following their initial contact with tritium, to schedule the first routine bioassay. Upon completion of this first bioassay, a bioassay schedule shall be established by RSS.

(iv) Any individual involved in a radiological incident who may have exceeded the allowable limits shall notify RSS immediately.

(v) Any individual who is participating in this program shall notify RSS prior to terminating employment or leaving TTUHSC.

(vi) Bioassays shall be performed by individuals designated by the RSO and shall be conducted in accordance with an accepted bioassay procedure.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Section 6
Radioactive Waste Disposal

6.1 General

Federal, state, and local statutes and regulations strictly govern disposal of radioactive waste. To assure disposal compliance, the following requirements and procedures for disposal of the various types of waste shall be observed. Radioactive waste generated at Texas Tech University Health Sciences Center (TTUHSC) may be disposed by five methods, and each type of disposal shall meet applicable federal, state, and/or local regulations. The disposal methods are as follows:

(a) Discharge into sanitary sewer system;

(b) Release to atmosphere;

(c) Specific waste;

(d) Radioactive decay; and/or

(e) Shipment off site.

6.2 Discharge into Sanitary Sewer System

(a) Disposal of more than trace amounts of radioactive material by discharge into the sanitary sewer system by Sublicensees is not permitted.

(b) Liquid radioactive waste will be collected in a suitable bulk liquid waste container.

(c) When washing glassware, pour first rinse into the liquid radioactive waste container. Additional rinses may be poured into the sanitary sewer drain. Residual radioactive material in the glassware after properly disposing of the first rinse should be minimal. Radiation Safety Services (RSS) uses a conservative guideline approximating that only about one percent of the total activity contained in the liquid waste container would enter the sanitary sewer during washing. This loss is considered when RSS calculates and performs a liquid radioactive waste disposal into the sanitary sewer system.

(d) RSS personnel will perform disposal of bulk liquid radioactive waste into the sanitary sewer system. All disposals will meet applicable regulations.

6.3 Release to Atmosphere

(a) The following restrictions shall be observed when releasing gases, vapors, or fumes to atmosphere:

(1) Procedures involving the release of volatile or gaseous radioactive labeled compounds shall be performed in a properly functioning laboratory fume hood.

(2) The radioactive concentration of volatile or gaseous waste shall not exceed the limits specified in applicable regulations.

6.4 Specific Waste

(a) The following materials may be disposed without regard to radioactivity:

(1) 0.05 microcuries or less of ^{125}I, ^{3}H, or ^{14}C per gram of liquid scintillation counting solution. Liquid scintillation counting solutions meeting these limits shall be placed in separate containers for collection and disposal by RSS.

(2) 0.05 microcuries or less of ^{125}I, ^{3}H, or ^{14}C per gram of animal tissue averaged over the weight of the entire animal. Animal tissue meeting these limits shall be packaged separately for collection and disposal by RSS.

(b) Upon agency approval, solid waste containing radionuclides included in 25 Texas Administrative Code (TAC) §289.202(ggg)(7) may be disposed in a Type I municipal solid waste site, provided that concentration and total curie limits are not exceeded. All labels, tags, or other markings that would indicate that the material or its contents are radioactive must be removed, or otherwise obliterated or obscured. This waste will be collected for disposal by RSS.

(c) Nothing in this section relieves the authorized user of maintaining records showing the receipt, transfer, and discard of such radioactive material as specified in applicable regulations and/or this manual.

(d) Nothing in this section relieves the authorized user from complying with other applicable federal, state or local regulations governing any other toxic or hazardous property of these materials.

6.5 Decay

(a) RSS is the only institutional entity authorized to provide long-term retention (storage) of radioactive material for decay. RSS shall survey the residual activity of stored material after a suitable time interval. Decayed waste shall not be released to conventional waste streams until surveys indicate the waste is indistinguishable from background. These surveys shall be documented in the waste disposal records.

6.6 Shipment Off-Site

A licensed commercial waste disposal firm shall dispose of radioactive wastes not disposed of by any of the above methods.

6.7 Facility Decontamination

(a) It shall be the responsibility of the authorized user to decontaminate any laboratory or radioactive material use area that becomes contaminated.

(b) Upon vacating all premises where radioactive materials have been used, the authorized user shall ensure that all residual radioactivities are properly removed and disposed of in accordance with applicable regulations and/or this manual.

6.8 Additional Information

(a) Contact RSS if a particular waste disposal situation is not addressed in any of the above alternatives.

(b) For additional information concerning disposal of radioactive waste, contact RSS.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Section 7
Emergency Guidelines

7.1 General

(a) A radiation incident shall be defined as an accidental or unusual occurrence that causes an unplanned radiation exposure to personnel, or results in a spill or release of radioactive material in excess of 10 microcuries.

(b) In the event of a radiation incident, the guidelines outlined in Table I or in subsequent parts of this section shall be observed immediately.

(c) It is the responsibility of the Sublicensee to report to Radiation Safety Services (RSS) all incidents involving release of radioactive material in or around their approved radiation-use facilities, as soon as possible.

(1) The Sublicensee will initiate a written report of the incident within one (1) working day to RSS, using the "Report Of Incidents Involving Radioactive Material" form.

(2) If any of the required signatories are absent, their designees should sign in their absence.

(3) Questions on proper completion of this form should be directed to RSS.

7.2 Radioactive Material Spill or Other Unplanned Release

(a) In the event of an incident involving the unplanned release of significant activities of radioactive material, emergency objectives are as follows:

(1) Provide immediate emergency medical care for serious injuries;

(2) Notify RSS (after normal working hours, use Police Department emergency number);

(3) Radiological assistance may be necessary to advise medical personnel that patient treatment should take precedence over almost all concern for contamination control and radiation exposure;

(4) Minimize the amount of radioactive material entering the body through ingestion, inhalation, or absorption;

(5) Remove any radioactive contamination present on personnel;

(6) Prevent the spread of radioactive contamination from the area of the incident.

(b) Immediate action to be taken by senior laboratory personnel present at the time of the incident to achieve the above objectives is as follows:

(1) Evaluate the situation with regard to:

(A) Levels of external exposure

(B) Contamination by radionuclides.

(2) If external radiation levels are high, evacuate exposed personnel from the incident area.

(3) If the possibility of radioactive contamination exists, assure that evacuees are held locally until monitored for contamination.

(4) Confine contamination within the incident area to prevent further spread.

(A) If liquid, use absorbent material to keep from spreading.

(B) If possible, close off air circulation and seal windows and doors.

(5) To minimize the spread of contamination, prevent further personnel access to the contaminated area.

(6) Personnel will remove contaminated clothing and shoes prior to entering an unrestricted area.

(7) Locate and monitor all personnel who may be contaminated, perform simple decontamination, if necessary, and then re-monitor personnel.

(8) Obtain assistance from RSS as soon as possible, call for medical assistance if personal injury is involved, and administer first aid, as necessary.

7.3 Minor Spills or Releases and Contamination

(b) Most spills will involve only minor quantities of radioactivity (rarely in excess of microcurie amounts). Laboratory personnel can normally handle low-level

decontamination, however, it is advisable to call RSS for guidance. Even if the RSS representative should only observe and evaluate procedures, they may be able, through objective observation, to prevent the development of an undetected problem.

(c) These general guidelines will typically prove to be adequate for most spills or releases encountered. Additional direction is provided under "Personnel Decontamination" guidelines, below. Items (1), (2), and (3) can usually be accomplished by ANY laboratory technician available at the time a spill or release occurs. Items (4), (5), and (6) should only be undertaken by approved, and whenever possible, experienced laboratory radiation workers.

(1) Put on gloves to prevent contamination of hands. If hands are contaminated as a result of the incident, wash with soap and water prior to putting on gloves.

(2) Place absorbent paper or cloth on the spill to limit the spread of contamination.

(3) Mark off the contaminated area. Do not allow anyone to leave the vicinity of the spill or release prior to being monitored for contamination.

(4) Start decontamination procedures as soon as possible. Normal cleaning agents should be adequate. Keep cleaning supplies to the minimum needed to do the job and place into sealed bags after use. Proceed with the decontamination, working from the outer-most area towards the center of the spill or release.

(5) Place all contaminated objects into containers or plastic bags to prevent the spread of contamination.

(6) In the event of energetic beta or other penetrating radioactive contamination, assign a person equipped with a survey instrument to follow the work and watch for accidental spread of contamination. Protect the survey meter probe from contamination by sealing it in a small plastic bag or disposable glove.

7.4 Personnel Decontamination

(b) If personnel contamination is suspected, the following guidelines should be observed:

(1) Identify contaminated areas with a survey meter, if possible.

(2) Do not use decontamination methods that will spread localized radioactive material or increase penetration of the contaminant into the body due to abrasion of the skin.

(3) Avoid the use of highly alkaline soaps that may increase percutaneous absorption through irritation or abrasion.

(4) The same guidelines used for personal cleanliness will usually suffice to remove radioactive contaminants from the skin; however, the specific method used will depend upon the form (grease, oil, etc.) of the deposited contamination. Soap and water normally remove more than 99% of the contaminants. Lanolin-based cream may be used to compensate for local irritations of the skin caused by decontamination procedures.

(5) The following general personnel decontamination information may be useful:

(A) Remove any contaminated clothing or equipment prior to determining levels of skin contamination.

(B) Decontaminate any areas of the body found to be significantly higher in contamination than surrounding areas. This method is helpful in preventing the spread of contamination to other uncontaminated areas of the body during showering.

(C) If contamination is generally over body surfaces, a very thorough shower is necessary. Special attention should be given to areas such as hair, hands, and fingernails. Following showering and monitoring, the residual contamination can be removed by spot cleaning.

(D) Wash the skin thoroughly with mild soap and water, paying special attention to the areas between fingers and around fingernails. Repeat the procedures if monitoring indicates contamination remaining on the skin in amounts above 100 dpm per 100 square centimeters (cm^2) or on a discrete area of the anatomy.

(E) Apply a detergent liquid mixture (such as a 5% by weight aqueous solution of a mixture of 35% Tide or other similar detergent, and 65% Calgon or similar mild detergent). Repeat the procedure if results prove to be effective; or,

(F) Apply a detergent cream (such as 5% versene (sodium EDTA), 10% Tide, and 85% water mixture). Rub thoroughly into the skin for approximately one minute. Repeat the treatment as long as the results show that the contaminant is being removed.

(G) If contamination is at a wound site, medical personnel should monitor or perform the cleansing of the wound area.

7.5 Remedial Action

If initial efforts at decontamination DO NOT produce encouraging results, cover the contaminated area and seek assistance from the Radiation Safety Officer (RSO). The RSO may suggest various decontamination techniques for decontamination of the skin and hands to minimize the absorption of radioactive materials through the skin layers. These measures may include the following:

(a) Clipping of the fingernails to remove residual activity after washing;

(b) Wearing of a rubber glove on the contaminated hand(s) for up to 48 hours to induce and promote perspiration of the hands, as the induced perspiration has been reported as very effective in certain instances; and

(c) Some degree of fixed contamination may occur; the maximum release limits for hands, body surfaces, or personnel clothing and shoes for beta-gamma activity are 0.1 mr/hr at 2 cm direct reading, and/or 1000 dpm/cm^2 wipe reading.

Table 7-1
Radiation Emergency Guidelines

Type Emergency	Hazard	Immediate Precautions	Follow-Up
Minor Spills: (Usually small, microcurie amounts)	No immediate radiation hazard to personnel Contamination hazard: Low	(1) Notify all persons in area; (2) Confine spill immediately; (3) Notify Radiation Safety Officer (RSO); (4) Begin clean-up immediately.	Control traffic through area until cleared by Radiation Safety Officer
Major Spills: (Usually millicurie amounts)	May be great radiation hazard to personnel Contamination hazard: Personnel and equipment	(1) Notify all personnel to vacate area; (2) Make no attempt to clean up spill; (3) Switch off all fans and vacate room or area; (4) Provide temporary barricade and warning signs; (5) Notify RSO.	Decontamination of personnel and equipment (including spill) to be carried out by or under the supervision of the RSO
Incidents involving: - Dust - Mist - Fumes - Vapors - Gases	Possible internal radiation hazard due to possible ingestion or inhalation Contamination hazard: Easily spread when airborne	(1) Notify others to vacate room or area; (2) Close windows and block off all air circulating intakes; (3) Provide temporary barrier and warning signs; (4) Notify RSO.	Do not re-enter until approved by RSO
Injuries Involving: - Radiation Hazard - Contamination	Contamination: Wounds are usually greatest hazard – route of entry for internal exposure	(1) Wash wound immediately in clean, running water; (2) Call physician; (3) Notify RSO.	Do not permit any individuals involved in the incident to return to work until approved by the RSO and physician
Fires Involving: - Radioactivity	Radiation: Internal hazard from airborne activity Contamination: May be spread by fire fighting techniques	(1) Notify all persons in rooms and building immediately; (2) Attempt to extinguish fire if radiation hazard is not immediately present; (3) Call fire department; (4) Notify RSO.	Emergency activities will be governed by or in cooperation with RSO

Note: In no event will anyone involved in the radiation incident be allowed to leave the general area until instructed to do so by the Radiation Safety Officer.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix A
Forms

Texas Tech University Health Sciences Center

Application for Short-Term/Temporary Approval for Supervised Work with Radioactive Materials

Full Name: _____ _____ _____
Last First Middle (Maiden)

_____ _____ _____
Title Department Sublicensee

_____ _____ _____
Laboratory Room Numbers Laboratory Telephone Number Location (Campus)

Proposed Dates of Work (Period of Approval): _____

Isotopes to be used: _____

Description of Utilization/Work to be done: _____

_____

_____

Applicant Statement: I understand that this approval is temporary, and is given only for the period specified and for the activities listed or described above. I understand the hazards associated with the use of radioactive materials and agree to follow prescribed rules, regulations, and safe work practices. I understand that all work must be performed under the supervision and direction of, and in the manner prescribed by the sublicensee.

_____ _____
Applicant Signature Date

Sublicensee Statement: I am familiar with the proposed studies and techniques listed or described above, and agree to allow these studies and techniques to be performed in my radiation laboratory areas. I accept responsibility for instructing the applicant in the proper techniques and procedures to be used and for supervision of the handling and use of radioactive materials used in the above listed or described activities.

_____ _____
Sublicensee Signature Date

Application Approved: ☐ Yes ☐ No

_____ _____
Radiation Safety Officer Signature Date

Approval Period: From _____ To _____

Special Conditions of Approval: _____

_____

_____

Texas State Government Privacy Policies (Government Code):
1) With few exceptions, you are entitled on request to be informed about the information the state governmental body collects about you; 2) Under Section 552.021 and 552.023, you are entitled to receive and review the information; and 3) Under Section 552.004, you are entitled to have the state governmental body correct information about you that is incorrect.

Texas Tech University Health Sciences Center

Radiation Exposure Investigation Report

The dosimetry vendor reported an exposure of _____ mRem on _____ (Date).

Name of individual exposed: _____ SSN: _____

Badge/Monitor Number: _____ Badge/Monitor Type: _____

Monitoring Period: _____ Sublicensee/Supervisor: _____

Department: _____ Estimated Date of Exposure: _____

Location/Room Number: _____

Cause of Exposure: _____

_____

_____

_____

Specify source of radiation involved: _____

_____

List all personnel involved in the exposure incident and any additional information regarding the exposure: _____

_____

_____

_____

_____ _____

Signature of Individual Exposed Date

_____ _____

Signature of Sublicensee/Supervisor Date

_____ _____

Signature of Department Head Date

_____ _____

Signature of Radiation Safety Officer Date

Please Contact Radiation Safety Services for questions or comments regarding this report at 806-743-2597.

Texas State Government Privacy Policies (Government Code):

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Texas Tech University Health Sciences Center

Application for Radioactive Material Sublicense
(Non-Human Use)

Please type or print clearly

1. Name of Applicant:	**2. Department:**
3. Office Location:	**4. Laboratory Location Where Radioactive Material Will Be Used:**
5. Office Phone:	**6. Laboratory Phone:**
7. Radiation Workers (include documentation of training):	**8. Present or Previous Radioactive Material Permit(s) Held:**

9. Radioactive Isotope Information

Element and Mass Number:	Physical Form:	Maximum Activity Requested (mCi):

Use continuation sheet (Page 3) as necessary

Identify the primary use of each radioactive isotope listed above, including the anticipated activity to be used per study. Use continuation sheet (page 3) as necessary.

Texas Tech University Health Sciences Center
Application for Radioactive Material Sublicense
(Non-Human Use)

Applicant Name: _____

10. Provide the following information (use continuation sheets or attach additional sheets or documents as necessary):

A. Facilities and equipment – Describe laboratory facilities, counting equipment, "hot" sinks, radioactive material storage areas, "hot" fume hoods, "hot" refrigerators or freezers, etc. for all radioactive laboratory rooms, storage areas or cold rooms. Include a diagram or map of all requested radiation use areas, identifying the locations of the equipment listed above.

B. Radiation Detection Instrumentation – Identify the brand, model number and serial number of all anticipated radiation measuring and monitoring equipment to be used. Include the instrument sensitivity, range, accessories, and detector type.

C. Radiation Analysis Instrumentation – Identify and locate any liquid scintillation counters, gamma counters, etc. to be used in laboratory analysis and removable contamination surveys.

11. Attach a completed "Application for Personal Dosimetry Service" (Form A-8) for the applicant and each requested radiation worker.

12. List applicable prior radioactive material use, training and experience. Use continuation sheets, if necessary, or attach documentation of training and experience.

Radioactive Isotopes and Activity Used	Approximate Dates of Work	Description of Training or Experience*	Name & Address of Preceptor

*** Note:** Please provide copies of any applicable published works in which radioactive isotopes were used. If no publications are available, please have your preceptor sign below to verify radioactive isotope training and experience.

_____ _____
Signature of Preceptor Date

_____
Typed or Printed Name of Preceptor

Texas Tech University Health Sciences Center
Application for Radioactive Material Sublicense
(Non-Human Use)

Continuation Sheet

Applicant Name: _____

Please indicate item number of continued information. This page may be reproduced as often as necessary.

Texas Tech University Health Sciences Center
Application for Radioactive Material Sublicense
(Non-Human Use)

Continuation Sheet

Applicant Name: _____

Certification

I certify that the information contained in and/or attached to this application is true and correct to the best of my knowledge.

I certify that I have read and understand the rules and regulations contained in the Texas Tech University Health Sciences Center *Radiation Safety Manual* governing the possession and use of radioactive material and radiation producing devices, and agree to comply with all applicable federal, state, and local rules and regulations pertaining to my use of radioactive materials.

I agree to wear appropriate personal radiation dosimetry devices or other required radiation monitoring devices during all activities involving the use radioactive material or possible radiation exposure as required by applicable rules and regulations.

For, and in consideration of, the mutual covenants and other good and valuable consideration, I do hereby release, discharge, and hold harmless Texas Tech University Health Sciences Center, its successors and assigns, from any and all claims and liabilities whatsoever which I may have, arising out of my use of such radiation producing sources.

_____ _____
Signature of Applicant **Position or Title**

_____ _____
Typed or Printed Name of Applicant **Date**

_____ _____
Signature of Department Chair **Date**

_____
Typed or Printed Name of Department Chair

Texas State Government Privacy Policies (Government Code):
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Texas Tech University Health Sciences Center

Radioactive Material Sublicense Amendment/Renewal Request

Please type or print clearly
(Use additional sheets as necessary)

Sublicensee: _____ **Office Phone Number:** _____

1. ☐ **Renewal:** For Radioactive Material Sublicense renewal only, with no changes, check item 1, obtain required signatures and return this completed form with a copy of the current Sublicense to Radiation Safety Services.

2. ☐ **Amendment:** For Radioactive Material Sublicense amendment or amendment/renewal, complete applicable sections, obtain required signatures and return this completed form with a copy of the current Sublicense to Radiation Safety Services.

3. Specify changes to Radiation Laboratories and/or Radiation Storage Rooms below.

	Radiation Laboratories	**Radiation Storage Rooms**
Add:		
Delete:		

Note: If adding a new Radiation Laboratory or Radiation Storage Room, please include a map of the applicable areas and identify proposed radiation use and/or radioactive storage areas.

4. Specify changes in isotopes, activity levels and proposed use below.

Change Desired	**Isotope**	**Current Activity (mCi)**	**Activity Change (+ or -) Requested (mCi)**	**Proposed New Activity (mCi)**	**Proposed Use**
☐ Addition ☐ Deletion ☐ Activity Increase ☐ Activity Decrease					

5. Specify changes to Radiation Workers, including documentation of experience and training for each.

	Radiation Worker Names	**Experience and Training**
Add:		
Delete:		

Note: When adding Radiation Workers, a completed "Application for Personal Dosimetry Service" (Form A-8), and verification of radiation safety training must be submitted with this amendment request form.

Sublicensee Signature: _____ **Date:** _____

Department Chair Signature: _____ **Date:** _____

Department Chair Typed Or Printed Name: _____ **Date:** _____

Texas State Government Privacy Policies (Government Code):
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TEXAS TECH UNIVERSITY
HEALTH SCIENCES CENTER
RADIOACTIVE MATERIAL RECEIPT AND ACCOUNTABILITY RECORD

USER NO.: _____ P.O.#: _____ SHIPMENT NO: _____
USER: _____
RECPT DATE: _____ ISOTOPE: _____ ACTIVITY: _____ mCi
VENDOR: _____ FORMULATION: _____

SHIPMENT INSPECTION

PACKAGING AND SEALS:

EXTERNAL RADIATION READING: mR/hr @ 1 meter.

CONTAMINATION SURVEY: EXTERNAL SURFACE: dpm/wipe

INTERNAL PACKAGING / VIAL: dpm/wipe

COMMENTS: _____

_____

SHIPMENT RECEIVED BY: _____ DATE: _____
_____

ACCOUNTABILITY RECORD

ACTIVITY USED(mCi)	DATE DISPOSED	TYPE OF WASTE DISPOSED TO:	REMARKS	INITIALS
		___DRY ___BULK LIQ. ___LSV ___OTHER		
		___DRY ___BULK LIQ. ___LSV ___OTHER		
		___DRY ___BULK LIQ. ___LSV ___OTHER		
		___DRY ___BULK LIQ. ___LSV ___OTHER		
		___DRY ___BULK LIQ. ___LSV ___OTHER		
		___DRY ___BULK LIQ. ___LSV ___OTHER		

THE CONTENTS OF THIS SHIPMENT HAVE BEEN COMPLETELY ACCOUNTED FOR AS INDICATED ABOVE. USER SIGNATURE: _____ DATE: _____

Return ACCOUNTABILITY FORM to RSS when all material is expended.

CONTINUATION PAGE
RADIOACTIVE MATERIAL RECEIPT AND ACCOUNTABILITY RECORD

USER: ____________________ SHIPMENT NO: ___________ RECPT DATE: ________

ISOTOPE: ____________________ FORMULATION: ______________________________

ACTIVITY USED (mCi)	DATE DISPOSED	TYPE OF WASTE DISPOSED TO:	REMARKS	INITIALS
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		
		___DRY ___BULK LIQ ___LSV ___OTHER		

THE CONTENTS OF THIS SHIPMENT HAVE BEEN COMPLETELY ACCOUNTED FOR AS INDICATED ABOVE. USER SIGNATURE: ___________________________DATE:_________

RSS Form A-05a
(Revised 10/21/88)

Return ACCOUNTABILITY FORM to RSS when all material is expended.

RADIOACTIVE WASTE DISPOSAL RECORD

1. SUBLICENSEE GENERATING WASTE: _____
2. DEPARTMENT: _____ 3. PHONE NO: _____
4. TYPE OF WASTE: (Circle one)
   BULK LIQUID, SOLID, CARCASS, LIQUID SCINTILLATION VIALS, PRIMARY VIALS
   (Circle one) AQUEOUS, ORGANIC, NOT APPLICABLE
5. ORGANIC: LIST CHEMICALS AND CONCENTRATION _____

PLEASE PRINT LEGIBLY

6. Enter the following information in the appropriate columns each time waste is deposited in the radioactive waste container. Use a separate line for each Isotope placed into the waste. Please indicate an approximate weight or volume in the last column for each batch of disposed waste.

DATE OF DISPOSAL	NAME	LAB NO.	ISOTOPE	ACTIVITY (mCi)	WEIGHT (gm or ml)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					

[ENTER TOTAL ACTIVITY FOR EACH ISOTOPE ABOVE]

ISOTOPE_____ : _____mCi ISOTOPE_____ : _____mCi ISOTOPE_____ : _____mCi

ISOTOPE_____ : _____mCi ISOTOPE_____ : _____mCi ISOTOPE_____ : _____mCi

SIGNATURE OF SUBLICENSEE OR TECHNICIAN_____ DATE_____

SIGNATURE OF SAFETY PERSONNEL_____ DATE_____

WASTE LOG NUMBER_____ BOX NUMBER_____ WEIGHT_____ VOLUME_____

DISTRIBUTION: WHITE TO SAFETY DEPARTMENT FILE, COPY TO SUBLICENSEE

RSS Form A-06
(Revised 07/96)

Texas Tech University Health Sciences Center

Radioactive Material Incident Report

THIS FORM MUST BE FILED IMMEDIATELY WITH THE RADIATION SAFETY OFFICER

Sublicensee: _____ **Date of Incident:** _____

Department: _____ **Date Report Completed:** _____

Location of Incident:: _____

Describe the incident (i.e. inadvertent exposure of personnel, spill, contamination): _____

_____

_____

How did the incident occur? _____

_____

_____

What isotopes and activities (mCi) were involved? _____

_____

List all personnel involved in the incident: _____

_____

_____

Describe corrective action taken, including decontamination procedures and the results of any radioactive contamination surveys (attach additional pages, if necessary):

_____

_____

_____

_____ _____

Sublicensee Signature **Date**

_____ _____

Department Chair Signature **Date**

_____ _____

Radiation Safety Officer Signature **Date**

Texas State Government Privacy Policies (Government Code):
1) With few exceptions, you are entitled on request to be informed about the information the state governmental body collects about you; 2) Under Section 552.021 and 552.023, you are entitled to receive and review the information; and 3) Under Section 552.004, you are entitled to have the state governmental body correct information about you that is incorrect.

Texas Tech University Health Sciences Center

Application for Personal Dosimetry Service

Please type or print clearly

Full Name: _____ _____ _____
Last First Middle (Maiden)

_____ _____ ☐ Male ☐ Female
Social Security Number Date of Birth
(If you do not have a Social Security Number, enter Passport Number and country of origin)

_____ _____
Department Principle Investigator

_____ _____ _____
Laboratory Location Laboratory Phone Office Phone

Have you previously worked at TTUHSC? ☐ Yes ☐ No If Yes, please complete the following:

_____ Date of Employment: _____ _____
Department From To

Have you had previous training/experience in radiation safety (other than while employed at TTUHSC)?
☐ Yes ☐ No (If "Yes" attach copies of documentation/certification)
Have you ever been enrolled in a radiation dosimetry/monitoring program before? ☐ Yes ☐ No
(If "Yes" complete the *Occupational Exposure History* information below)

OCCUPATIONAL EXPOSURE HISTORY

List only those employers for whom you worked with radiation and were enrolled in a radiation dosimetry/monitoring program

Employer	Address	From (Month, Year)	To (Month, Year)	Department

Texas Regulations for Control of Radiation may require under certain circumstances, that upon termination of employment or association with TTUHSC, a report of radiation exposure be furnished to any individual who may have received occupational exposure to radiation while employed by TTUHSC. Please provide a forwarding address to which this information may be sent upon termination of employment or association with TTUHSC.

Street Address or P.O. Box: _____

City: _____ State: _____ Zip Code: _____

Texas Tech University Health Sciences Center is granted permission to obtain my previous radiation exposure history from any previous employers listed above. To the best of my knowledge, the above information is true and correct.

Signature: _____ Date: _____

Return completed form to: TTUHSC Radiation Safety Services; 3601 4th Street, STOP 9020; Lubbock, TX 79430-9020

Texas State Government Privacy Policies (Government Code):
1) With few exceptions, you are entitled on request to be informed about the information the state governmental body collects about you; 2) Under Section 552.021 and 552.023, you are entitled to receive and review the information; and 3) Under Section 552.004, you are entitled to have the state governmental body correct information about you that is incorrect.

Texas Tech University Health Sciences Center

Bioassay Record

Please type or print clearly

Full Name: _____ _____ _____
Last First Middle (Maiden)

_____ _____ ☐ Male ☐ Female
Social Security Number Date of Birth

_____ _____
Department Principle Investigator

_____ _____ _____
Laboratory Location Laboratory Phone Office Phone

Date and Time of last Use: Date Time

Isotope(s) Used (check all that apply): _____ _____ _____

_____ _____ _____

_____ _____ _____

Type of Bioassay (check one): ☐ Baseline ☐ Diagnostic ☐ Routine ☐ Emergency ☐ Post-operational

---

Instrument Manufacturer: _____ Instrument Type: _____

Model No: _____ Serial No: _____ Calibration Date: _____

Detector/Probe Manufacturer: _____ Model No: _____

Serial No: _____

Background: _____ cpm Efficiency (percent): _____

Specimen A: _____ cpm Net dpm (Net cpm/Eff): _____ dpm

Specimen B: _____ cpm Conversion Factor (dpm to µCi): 2.22E^{-6}

Average [(A + B)/2]: _____ cpm Net Activity (dpm/Conv. Factor): _____ µCi

Net cpm (Avg - Bkgd): _____ cpm

Comments:

Bioassay performed by:

_____ _____ _____
Signature Print Name Date

Texas State Government Privacy Policies (Government Code):

1) With few exceptions, you are entitled on request to be informed about the information the state governmental body collects about you; 2) Under Section 552.021 and 552.023, you are entitled to receive and review the information; and 3) Under Section 552.004, you are entitled to have the state governmental body correct information about you that is incorrect.

RSS Form A-09G
(Revised 11/03)

Texas Tech University Health Sciences Center

Bioassay Record

Please type or print clearly

Full Name: _____ _____ _____
Last First Middle (Maiden)

_____ _____ ☐ Male ☐ Female
Social Security Number Date of Birth

_____ _____
Department Principle Investigator

_____ _____ _____
Laboratory Location Laboratory Phone Office Phone

Date and Time of last Use: Date Time

Isotope(s) Used (check all that apply):

☐ ^{125}I _____ _____

☐ ^{131}I _____ _____

☐ Other: _____ _____ _____

Type of Bioassay (check one): ☐ Baseline ☐ Diagnostic ☐ Routine ☐ Emergency ☐ Post-operational

---

Survey Instrument Manufacturer: _____ Model No: _____

Serial No: _____ Calibration Date: _____

Detector/Probe Manufacturer: _____ Model No: _____

Serial No: _____

Background: _____ cpm

Neck Swab: _____ cpm Correction Factor (CF): _____ µCi/cpm

Neck Contact: _____ cpm Constancy Correction Factor (CCF): _____

Thigh Contact: _____ cpm Thyroid Burden = CC + CF + CCF = _____ µCi

Net Contact (CC): _____ cpm ☐ ^{125}I ☐ ^{131}I ☐ Other: _____

Comments:

Bioassay performed by:

_____ _____ _____
Signature Print Name Date

Texas State Government Privacy Policies (Government Code):

1) With few exceptions, you are entitled on request to be informed about the information the state governmental body collects about you; 2) Under Section 552.021 and 552.023, you are entitled to receive and review the information; and 3) Under Section 552.004, you are entitled to have the state governmental body correct information about you that is incorrect.

RSS Form A-09T
(Revised 11/03)

Texas Tech University Health Sciences Center
Radiation Dose Assessment

Please type or print clearly
(Use additional sheets as necessary)

1. Employee Name	2. Date of Birth	3. Social Security Number
4. Badge Series Code	5. Badge Number	6. Monitoring Period

7. Dose Reported	8. Dosimetry Vendor

9. Type of Monitoring Device Used		10. Type of Radiation Measured
☐ OSL ☐ TLD	☐ Whole-Body ☐ Extremity ☐ Fetal	☐ Gamma Ray ☐ X-Ray ☐ Beta

11. Results of Investigation (If badge was lost, describe when and how lost)

12. Corrective Action (If lost badge, what action will be taken to prevent future loss)

13. Method of Calculation of Assessed Dose

Employee Signature _____ Date _____

Sublicensee Signature _____ Date _____

Department Chair Signature _____ Date _____

Radiation Safety Officer Signature _____ Date _____

Texas State Government Privacy Policies (Government Code):

1) With few exceptions, you are entitled on request to be informed about the information the state governmental body collects about you; 2) Under Section 552.021 and 552.023, you are entitled to receive and review the information; and 3) Under Section 552.004, you are entitled to have the state governmental body correct information about you that is incorrect.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix B
Waste Disposal Guidelines

B.1 General

(a) Texas Tech University Health Sciences Center (TTUHSC) "Specific Waste" as defined in Section 6.4, page 6-2 of this manual, shall be deposited in the West Texas Regional Disposal Facility, located at 17304 N. FM 2528, Abernathy, TX 79311. The facility is located approximately 15 miles North of the intersection of N. Frankford Avenue and 4th Street, Lubbock, TX, and approximately 6 miles West of the intersection of I-27 and FM 597, Abernathy, TX. All road surfaces leading to the facility are paved, all-weather surfaces, maintained by city, county, and state maintenance services.

(b) Specific waste that satisfies the criterion of 25 TAC §289.202(fff) will be transported to the West Texas Regional Disposal Facility in a vehicle owned or leased, and operated by Texas Tech University (TTU), Texas Tech University Health Sciences Center (TTUHSC), or TTUHSC Safety Services (SS). The vehicle used will be enclosed on top and all sides, such as a step van, cargo van, or covered pickup truck. Personnel delivering the specific waste to the disposal facility will be TTUHSC Radiation Safety Services (RSS) personnel, or other TTUHSC personnel who have been specifically trained in the methods and appropriate guidelines for safe handling of the types of waste involved.

B.2 Quality Control

(a) Assurance of the contents of waste containers will primarily be derived from information listed on the "Radioactive Waste Disposal Record" (RSS Form A-06). The types and activities of radioisotopes contained in the waste containers should be compared with the radioisotopes and activity limits of the Radioactive Material Sublicensee generating the waste.

(b) If the results of the above assurance process warrant, or if the waste is from a laboratory in which "other" isotopes are used, quality control sampling may be conducted on the contents of the waste container for analysis by RSS personnel.

(c) A representative number (not less than ten percent or more than 25 percent) of the waste containers awaiting disposal will have quality control sampling performed on the contents. Quality control sampling is conducted for the purpose of insuring compliance with 25 TAC §289.202(fff)(5). The following types of analysis will be performed:

(1) A gross gamma survey will be conducted on all waste packages using an appropriate portable survey instrument. The survey will be performed slowly and methodically, scanning the outer surfaces of the waste container with the instrument. This survey is performed to check for potentially high concentrations of

gamma emitting isotopes. The gross gamma survey will be the only survey conducted on containers of frozen tissue and/or animal carcass waste.

(2) Dry (solid) and liquid scintillation vial waste containers selected for quality control checks shall be opened by RSS personnel, and a representative number (not less than 5, no more than 20) of contamination wipe samples shall be taken from the contents of the waste container. The samples shall be taken from random locations throughout the container. These samples will be analyzed using a liquid scintillation counting system, and/or a gamma scintillation counting system, whichever is appropriate for the waste involved, to verify the absence of unauthorized isotopes.

(3) Bulk liquid waste containers selected for quality control checks shall be opened by RSS personnel, and after thorough mixing, a representative number of liquid samples (greater than or equal to 2, less than or equal to 5) shall be taken from the contents of the waste container. The samples will be analyzed by liquid scintillation counting using a wide spectrum program to verify the absence of unauthorized isotopes.

(4) When quality control analysis indicates the presence of radioactive material other than that specified in 25 TAC §289.202(fff)(1) or 25 TAC §289.202(ggg)(7), the particular waste package will be classified and processed for commercial disposal or storage. The Radioactive Material Sublicensee generating the waste will be informed of the situation and instructed in the methods of proper radioisotope waste segregation. In the event of a recurrence of this problem from the same Sublicensee, the situation will be brought to the attention of the Radiation Safety Committee (RSC) for review, evaluation, and determination of any disciplinary action necessary.

(5) The results of all quality control analysis will be maintained as required by 25 TAC §289.202(fff)(7).

B.3 Packaging

(a) TTUHSC specific waste will be separated according to physical type at the point of generation (user location). The six (6) primary physical types include the following:

(1) Dry/solid waste;

(2) Aqueous liquid scintillation vials;

(3) Organic liquid scintillation vials;

(4) Aqueous bulk liquid;

(5) Organic bulk liquid; and

(6) Animal tissue/carcass waste.

(b) Dry/solid waste

(1) Dry/solid waste will typically be collected at the user location in 38-gallon "ROCON" type fiberboard containers lined with at least two (2) heavy-gauge poly liners; in lined, 5-gallon containers; or in lined, specially-constructed containers designed for collection or storage of radioactive waste. When full, all containers will be collected from the user location and delivered to the RSS waste staging area by RSS personnel. Those containers requiring commercial disposal or on-site storage for reasons of hazardous material content or radioactive material, will be packaged for disposal by RSS personnel in the processing room. Packaging will be as required by the commercial disposal company or by applicable regulation.

(2) Dry/solid waste that satisfies the criterion of 25 TAC §289.202(fff) will be placed, whenever practicable, into corrugated boxes in preparation for disposal in the approved municipal solid waste facility. The only markings on these boxes will be the RSS assigned waste inventory number; the initials of the RSS personnel preparing the box; the weight of the box; and the date the box was sealed. Prior to sealing the boxes, RSS will insure through the quality assurance checks and/or through administrative verification that the radioactive material concentrations satisfy the criterion of 25 TAC §289.202(ggg)(7).

(c) Liquid scintillation vials

(1) Liquid scintillation vials will typically be collected at the user location in 38-gallon "ROCON" type fiberboard containers lined with at least two (2) heavy-gauge poly liners; in lined, 5-gallon containers; or in lined, specially-constructed containers designed for collection or storage of liquid scintillation vial waste. When full, all containers will be collected from the user location and delivered to the RSS waste staging area by RSS personnel. Those containers requiring commercial disposal or on-site storage for reasons of hazardous material content (organic liquid scintillation cocktail) or radioactive material, will be packaged for disposal by RSS personnel in the processing room. Packaging will be as required by the commercial disposal company or by applicable regulation.

(2) General liquid scintillation vial packaging guidelines are as follows:

(A) Open and inspect the empty 55-gallon steel disposal drum for holes or leaks. Replace drum if found defective;

(B) Place a heavy-gauge poly liner in the drum;

(C) Place 4 to 6 inches of absorbent in the liner within the drum;

(D) Place a second heavy-gauge ploy liner in the drum;

(E) Add liquid scintillation vials to within no less than 3 inches from the top of the drum (do not add absorbent to the inner liner with the vials);

(F) Prior to sealing the container, RSS will insure through quality assurance checks and/or through administrative verification that the radioactive material concentrations contained in the drum satisfy applicable transport and disposal regulations.

(G) Close and seal the inner and outer liners, close the drum and install the locking ring;

(H) These guidelines will be observed unless the commercial disposal company or applicable regulations specify otherwise;

(I) The only markings on these containers will be the RSS assigned waste inventory number; the initials of the RSS personnel preparing the container; and the date the container was sealed.

(d) Aqueous bulk liquid waste

(1) Aqueous bulk liquid waste will be collected in poly carboys or similar containers with a capacity of 5 gallons or less. When full, all containers will be collected from the user location and delivered to the RSS waste staging area by RSS personnel. Those containers requiring commercial disposal or on-site storage for reasons of hazardous material content (organic liquids) or radioactive material, will be packaged for disposal by RSS personnel in the processing room. Packaging will be as required by the commercial disposal company or by applicable regulation. The only markings on these containers will be the RSS assigned waste inventory number; the initials of the RSS personnel preparing the container; and the date the container was sealed. Prior to sealing the container, RSS will insure through quality assurance checks and/or through administrative verification that the radioactive material concentrations contained in the carboy satisfy applicable regulations.

(2) Bulk liquid waste that satisfies the criterion of 25 TAC §289.202(gg) may be disposed of by release into the sanitary sewer system.

(e) Organic bulk liquid waste will be collected in poly carboys or similar containers with a capacity of 5 gallons or less. When full, all containers will be collected from the user location and delivered to the RSS waste staging area by RSS personnel. Those containers requiring commercial disposal or on-site storage for reasons of hazardous material content (organic liquids) or radioactive material, will be packaged for disposal by RSS personnel in the processing room. Packaging will be as required by the commercial disposal company or by applicable regulation. The only markings on these containers will be the RSS assigned waste inventory number; the initials of the RSS personnel preparing the container; and the date the container was sealed. Prior to sealing the container, RSS will insure through quality assurance checks and/or through administrative verification that the radioactive material concentrations contained in the carboy satisfy applicable regulations.

(f) Animal tissue/carcass waste

(1) Animal tissue/carcass waste containing radioactive material that satisfies the criterion of 25 TAC §289.202(fff) for disposal in the approved municipal solid waste facility will be sealed in heavy-gauge poly bags at the user location. These bags will then be sealed in a secondary heavy-gauge poly bag. The user will place an identifying tag/label on the outer bag that will include the following information:

(A) The name of the Sublicensee;

(B) The initials of the individual preparing the waste;

(C) The date of waste preparation;

(D) The weight of the animal tissue/carcass waste;

(E) The radioisotope(s) contained in the waste; and

(F) The activity of each isotope in the waste.

(2) The animal tissue/carcass waste will be kept in a locked freezer at the user location while awaiting disposal by RSS.

(3) If the waste satisfies the criterion of 25 TAC §289.202(fff) for disposal in the approved municipal solid waste facility and commercial disposal or storage is not required, the waste will be collected by RSS personnel and prepared for disposal. The waste bag(s) will be placed in a corrugated box, and RSS personnel will

remove the waste identification tag/label and label the box with only the RSS assigned waste inventory number; the initials of the RSS personnel preparing the container; and the date the container was sealed. If the animal tissue/carcass waste satisfies the criterion of 25 TAC §289.202(fff) for disposal in the approved municipal solid waste facility, disposal will be the same as that specified for dry/solid waste meeting the same criteria.

(4) If the animal tissue/carcass waste requires commercial disposal, packaging will be as required by the commercial disposal company or by applicable regulations.

(g) The obliteration and/or removal of "Radioactive" signs, symbols, and markings will be accomplished either at the time RSS delivers the radioactive material to the authorized user, or by the user prior to placing the containers into the laboratory dry waste container. Periodic quality control compliance surveys and audits will provide RSS an opportunity to verify compliance. Compliance with 25 TAC §289(fff)(5)(B) will be through the double packaging of waste material.

B.4 Processing

(a) Liquid Scintillation Vials fully consisting of biodegradable liquid scintillation cocktail, containing less than 1 percent toluene, xylene, or benzene per unit volume, will be processed in the S&G Enterprises. Inc., Model II-X Vyleater vial crusher unit. The process will produce two individual waste streams consisting of dry/solid specific waste and aqueous bulk liquid waste.

(1) Dry/solid specific waste, consisting of crushed plastic and/or glass vials, will be dispensed from the crusher into a 38-gallon ROCON fiberboard container lined with at least two heavy-gauge poly liner bags for storage pending disposal.

(2) The aqueous bulk liquid waste will be collected from the crusher via a gravity drain hose into poly carboys or similar containers with a capacity of 5 gallons or less.

(3) The waste streams generated by the crushing process will be disposed according to the guidelines previously outlined for dry/solid specific waste and aqueous bulk liquid waste.

(b) General Processing Guidelines

(1) RSS personnel will confirm the type of liquid scintillation cocktail contained in the vials from research laboratories at the time the waste is collected from

the laboratory. The type of liquid scintillation cocktail will be indicated on the Radioactive Waste Disposal Form.

(2) Prior to commencing the crushing operation, the operator of the crusher unit will ensure that the liquid and dry/solid waste containers are empty and securely resting within secondary containment.

(3) The operator will verify that the internal separation screens of the crusher are properly in place and that the exhaust ventilation system is in place and operating.

(4) Upon completion of the crushing operation, the operator will decontaminate the internal screens and conveyor system of the unit, and perform a contamination wipe survey of the unit and surrounding floor area (this survey is in addition to the regular monthly surveys).

(5) The operator will inspect the dry/solid waste to ensure that all vials have been adequately crushed and emptied of liquid contents. All intact vials are crushed again.

(6) Waste disposal forms are completed for the dry/solid and liquid waste containers, utilizing the isotope and activity information provided on the original waste form for the scintillation vials. The activity of each specific isotope will be allocated at 90 percent to liquid waste and the remaining 10 percent to dry/solid waste.

(7) Dry/solid waste is processed and packaged in accordance with the guidelines for dry/solid specific waste, including quality control checks and direct reading surveys. Liquid waste is processed as aqueous bulk liquid and sampled to determine actual isotope and activity information. The dry/solid special waste and aqueous liquid waste are disposed as previously outlined in this appendix.

(8) If vials contain an organic, solvent-based scintillation cocktail or if there is uncertainty of the type of cocktail contained in the vials, or if the vial crushing unit is inoperable for an extended period of time, the vials will be packaged and processed for commercial disposal.

B.5 Waste Records

(a) The following records will be maintained coincidental to the collection, processing, and disposal of radiological/special waste:

(1) Radioactive Waste Disposal Record (RSS Form A-06)

(2) Radioactive Waste Quality Control Survey (RSS Form A-19)

(3) Waste Disposal Summary Report

(4) Commercial disposal receipts/records

(b) Waste forms may be changed or modified by RSS as necessary, however, the information collected and summaries made will satisfy the requirements of applicable regulations.

(c) Records will be maintained by RSS as specified by applicable regulations or until such time as TDH-BRC authorizes records disposal.

(d) Following is a brief explanation of each waste form and summary report:

(1) Radioactive Waste Disposal Record

(A) The "Radioactive Waste Disposal Record" (RSS Form A-06) is a carbonless, multi-page form that is provided to the various radioactive material users by RSS. As radioactive/special waste is deposited in the appropriate radioactive/special waste container, appropriate entries are made on the form for each radioactive isotope contained in the waste. Information entered on the form includes the following:

(i) Sublicensee name;

(ii) Department;

(iii) Telephone number;

(iv) Type of waste;

(v) Composition of waste (aqueous, organic, etc.);

(vi) Date of disposal (date waste deposited in container);

(vii) Name of individual depositing waste;

(viii) Laboratory room number;

(ix) Isotope disposed;

(x) Activity per isotope (in activity units specified on the form); and

(xi) Weight or volume of the disposed waste.

(B) The Sublicensee or radiation worker will total the activities and weights or volumes for each isotope listed on the form and record these totals in the appropriate section of the form.

(C) Upon completion of the form, RSS may be notified that the waste container is ready for disposal.

(2) The "Radioactive Waste Quality Control Survey" (RSS Form A-19) form will be used to Document external and internal quality control sampling of waste packages. All appropriate information identifying the contents of the waste container and the methods used to test the contents will be listed on and/or attached to the form.

(3) The "Special Waste and Animal Carcass Disposal Summary" (RSS Form A-14) will be used to summarize each disposal of waste containing special waste material.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix C
Amarillo Regional Campus Site-Specific Guidelines

C.1 General

(a) The Amarillo Regional Campus Safety Services Manager will serve as the designated representative of the Texas Tech University Health Sciences Center (TTUHSC) Radiation Safety Officer (RSO) for the Amarillo Regional Campus. The Manager will represent the TTUHSC RSO on matters concerning the administration of the TTUHSC Radiation Safety Program at the Amarillo Regional Campus.

(b) The Manager will possess appropriate, documented training and experience in radiation safety, to include as a minimum, the topics outlined in 25 TAC §289.252(ii)(1). In addition, the Manager will intern at TTUHSC – Lubbock to become familiar with administration of the overall TTUHSC Radiation Safety Program.

C.2 Regional Campus Safety Services Manager

(a) The Regional Campus Safety Services Manager acts as the designated representative of the TTUHSC RSO on matters concerning implementation of policies, practices, and guidelines established by the TTUHSC Radiation Safety Committee for the Amarillo Regional Campus.

(b) The responsibilities the Regional Campus Safety Services Manager include, but are not limited to the following:

(1) Terminate any operation that the Manager determines is causing a radiation hazard or is in violation of applicable regulations;

(2) Disseminate information concerning radiation safety and radiological health;

(3) Perform monthly audits of authorized radioactive material users;

(4) Receive, process and deliver all shipments of radioactive material received at the Regional Campus;

(5) Prepare all shipments of radioactive material to be shippded from the Regional Campus;

(6) Provide radioactive/special waste disposal services for all Sublicensees;

(7) Maintain comprehensive files and records of the receipt, use, storage, and disposal of radioactive material;

(8) Maintain comprehensive files and records on all matters pertinent to the Radiation Safety Program at the Regional Campus;

(9) Coordinate the use and distribution of personnel dosimetry devices;

(10) Except in extreme emergencies, obtain advice and guidance from the RSO for radiation safety matters not specifically addressed in the TTUHSC *Radiation Safety Manual*.

C.3 Radioactive Material Accountability

(a) Order approval for radioactive material will be processed through the Regional Campus Safety Services Office, coordinated with Radiation Safety Services – Lubbock to maintain continuity and proper sequencing of orders. Radioactive material will be ordered as outlined in Section 3 of the TTUHSC *Radiation Safety Manual*.

(b) Incoming shipments of radioactive material shall be delivered to the designated receiving area for the Regional Campus. The shipments will be placed in an area designated for temporary storage of radioactive material shipments.

(c) Shipping/receiving personnel will notify the Manager or designee when any radioactive material package has been received.

(d) The Manager or designee will take possession of the radioactive material package(s) and process them according to the guidelines of Section 3 and Section 5 of the TTUHSC *Radiation Safety Manual*.

(e) No radioactive material shipments will be accepted outside of normal business hours.

(f) A Radioactive Material Receipt and Accountability Record (RSS Form A-05) will be completed and delivered with the radioactive material to the Sublicensee, or the Sublicensee will be informed that the package has been processed and that arrangements can be made to pick up the package and receipt.

(g) Upon receipt of the radioactive material and forms, the Sublicensee will verify that the shipment arrived as ordered, then sign and date the receipt appropriately.

C.4 Radioactive Waste Disposal

(a) General

(1) Texas Tech University Health Sciences Center (TTUHSC) "Specific Waste" as defined in Section 6 of the TTUHSC *Radiation Safety Manual* shall be deposited in the Amarillo Municipal Landfill, located approximately 5.5 miles West of the Amarillo Regional Campus (1400 Wallace Blvd., Amarillo, TX), and approximately 1.5 miles North of Interstate 40 West off of Hill Road. All road surfaces leading to the facility are paved, all-weather surfaces, maintained by city, county, and state maintenance services.

(2) Specific waste that satisfies the criterion of 25 TAC §289.202(fff) will be transported to the Amarillo Municipal Landfill in a vehicle owned or leased, and operated by Texas Tech University (TTU), Texas Tech University Health Sciences Center (TTUHSC), or TTUHSC Safety Services (SS). The vehicle used will be enclosed on top and all sides, such as a step van, cargo van, or covered pickup truck. Personnel delivering the specific waste to the disposal facility will be TTUHSC Radiation Safety Services (RSS) personnel, or other TTUHSC personnel who have been specifically trained in the methods and appropriate guidelines for safe handling of the types of waste involved.

(b) Quality Control

(1) Assurance of the contents of waste containers will primarily be derived from information listed on the "Radioactive Waste Disposal Record" (RSS Form A-06). The types and activities of radioisotopes contained in the waste containers should be compared with the radioisotopes and activity limits of the Radioactive Material Sublicensee generating the waste.

(2) If the results of the above assurance process warrant, or if the waste is from a laboratory in which "other" isotopes are used, quality control sampling may be conducted on the contents of the waste container for analysis by RSS personnel.

(3) A representative number (not less than ten percent or more than 25 percent) of the waste containers awaiting disposal will have quality control sampling performed on the contents. Quality control sampling is conducted for the purpose of insuring compliance with 25 TAC §289.202(fff)(5). The following types of analysis will be performed:

(A) A gross gamma survey will be conducted on all waste packages using an appropriate portable survey instrument. The survey will be performed slowly and methodically, scanning the outer surfaces of the waste container

with the instrument. This survey is performed to check for potentially high concentrations of gamma emitting isotopes. The gross gamma survey will be the only survey conducted on containers of frozen tissue and/or animal carcass waste.

(B) Dry (solid) and liquid scintillation vial waste containers selected for quality control checks shall be opened by RSS personnel, and a representative number (not less than 5, no more than 20) of contamination wipe samples shall be taken from the contents of the waste container. The samples shall be taken from random locations throughout the container. These samples will be analyzed using a liquid scintillation counting system, and/or a gamma scintillation counting system, whichever is appropriate for the waste involved, to verify the absence of unauthorized isotopes.

(C) Bulk liquid waste containers selected for quality control checks shall be opened by RSS personnel, and after thorough mixing, a representative number of liquid samples (greater than or equal to 2, less than or equal to 5) shall be taken from the contents of the waste container. The samples will be analyzed by liquid scintillation counting using a wide spectrum program to verify the absence of unauthorized isotopes.

(D) When quality control analysis indicates the presence of radioactive material other than that specified in 25 TAC §289.202(fff)(1) or 25 TAC §289.202(ggg)(7), the particular waste package will be classified and processed for commercial disposal or storage. The Radioactive Material Sublicensee generating the waste will be informed of the situation and instructed in the methods of proper radioisotope waste segregation. In the event of a recurrence of this problem from the same Sublicensee, the situation will be brought to the attention of the Radiation Safety Committee (RSC) for review, evaluation, and determination of any disciplinary action necessary.

(E) The results of all quality control analysis will be maintained as required by 25 TAC §289.202(fff)(7).

(c) Packaging

(1) TTUHSC specific waste will be separated according to physical type at the point of generation (user location). The six (6) primary physical types include the following:

(A) Dry/solid waste;

(B) Aqueous liquid scintillation vials;

(C) Organic liquid scintillation vials;

(D) Aqueous bulk liquid;

(E) Organic bulk liquid; and

(F) Animal tissue/carcass waste.

(2) Dry/solid waste

(A) Dry/solid waste will typically be collected at the user location in 38-gallon "ROCON" type fiberboard containers lined with at least two (2) heavy-gauge poly liners; in lined, 5-gallon containers; or in lined, specially-constructed containers designed for collection or storage of radioactive waste. When full, all containers will be collected from the user location and delivered to the Regional Campus waste staging area by Regional Campus Safety Services personnel. Those containers requiring commercial disposal or on-site storage for reasons of hazardous material content or radioactive material, will be packaged for disposal by Regional Campus Safety Services personnel in the processing room. Packaging will be as required by the commercial disposal company or by applicable regulation.

(B) Dry/solid waste that satisfies the criterion of 25 TAC §289.202(fff) will be placed, whenever practicable, into corrugated boxes in preparation for disposal in the approved municipal solid waste facility. The only markings on these boxes will be the assigned waste inventory number; the initials of the personnel preparing the box; the weight of the box; and the date the box was sealed. Prior to sealing the boxes, personnel will insure through the quality assurance checks and/or through administrative verification that the radioactive material concentrations satisfy the criterion of 25 TAC §289.202(ggg)(7).

(3) Liquid scintillation vials

(A) Liquid scintillation vials will typically be collected at the user location in 38-gallon "ROCON" type fiberboard containers lined with at least two (2) heavy-gauge poly liners; in lined, 5-gallon containers; or in lined, specially-constructed containers designed for collection or storage of liquid scintillation vial waste. When full, all containers will be collected from the user location and delivered to the RSS waste staging area by RSS personnel. Those containers requiring commercial disposal or on-site storage for reasons of hazardous material content (organic liquid scintillation cocktail) or radioactive material, will be packaged for disposal by RSS personnel in the processing room. Packaging will be as required by the commercial disposal company or by applicable regulation.

(B) General liquid scintillation vial packaging guidelines are as follows:

(i) Open and inspect the empty 55-gallon steel disposal drum for holes or leaks. Replace drum if found defective;

(ii) Place a heavy-gauge poly liner in the drum;

(iii) Place 4 to 6 inches of absorbent in the liner within the drum;

(iv) Place a second heavy-gauge poly liner in the drum;

(v) Add liquid scintillation vials to within no less than 3 inches from the top of the drum (do not add absorbent to the inner liner with the vials);

(vi) Prior to sealing the container, RSS will insure through quality assurance checks and/or through administrative verification that the radioactive material concentrations contained in the drum satisfy applicable transport and disposal regulations.

(vii) Close and seal the inner and outer liners, close the drum and install the locking ring;

(viii) These guidelines will be observed unless the commercial disposal company or applicable regulations specify otherwise;

(ix) The only markings on these containers will be the assigned waste inventory number; the initials of the personnel preparing the container; and the date the container was sealed.

(4) Aqueous bulk liquid waste

(A) Aqueous bulk liquid waste will be collected in poly carboys or similar containers with a capacity of 5 gallons or less. When full, all containers will be collected from the user location and delivered to the RSS waste staging area by RSS personnel. Those containers requiring commercial disposal or on-site storage for reasons of hazardous material content (organic liquids) or radioactive material, will be packaged for disposal by RSS personnel in the processing room. Packaging will be as required by the commercial disposal company or by applicable regulation. The only markings on these containers will be the RSS assigned waste inventory number; the initials of the RSS personnel preparing the container; and the date the container was

sealed. Prior to sealing the container, RSS will insure through quality assurance checks and/or through administrative verification that the radioactive material concentrations contained in the carboy satisfy applicable regulations.

(B) Bulk liquid waste that satisfies the criterion of 25 TAC §289.202(gg) may be disposed of by release into the sanitary sewer system.

(5) Organic bulk liquid waste will be collected in poly carboys or similar containers with a capacity of 5 gallons or less. When full, all containers will be collected from the user location and delivered to the RSS waste staging area by RSS personnel. Those containers requiring commercial disposal or on-site storage for reasons of hazardous material content (organic liquids) or radioactive material, will be packaged for disposal by RSS personnel in the processing room. Packaging will be as required by the commercial disposal company or by applicable regulation. The only markings on these containers will be the RSS assigned waste inventory number; the initials of the RSS personnel preparing the container; and the date the container was sealed. Prior to sealing the container, RSS will insure through quality assurance checks and/or through administrative verification that the radioactive material concentrations contained in the carboy satisfy applicable regulations.

(6) Animal tissue/carcass waste

(A) Animal tissue/carcass waste containing radioactive material that satisfies the criterion of 25 TAC §289.202(fff) for disposal in the approved municipal solid waste facility will be sealed in heavy-gauge poly bags at the user location. These bags will then be sealed in a secondary heavy-gauge poly bag. The user will place an identifying tag/label on the outer bag that will include the following information:

(i) The name of the Sublicensee;

(ii) The initials of the individual preparing the waste;

(iii) The date of waste preparation;

(iv) The weight of the animal tissue/carcass waste;

(v) The radioisotope(s) contained in the waste; and

(vi) The activity of each isotope in the waste.

(B) The animal tissue/carcass waste will be kept in a locked freezer at the user location while awaiting disposal by RSS.

(C) If the waste satisfies the criterion of 25 TAC §289.202(fff) for disposal in the approved municipal solid waste facility and commercial disposal or storage is not required, the waste will be collected by RSS personnel and prepared for disposal. The waste bag(s) will be placed in a corrugated box, and RSS personnel will remove the waste identification tag/label and label the box with only the RSS assigned waste inventory number; the initials of the RSS personnel preparing the container; and the date the container was sealed. If the animal tissue/carcass waste satisfies the criterion of 25 TAC §289.202(fff) for disposal in the approved municipal solid waste facility, disposal will be the same as that specified for dry/solid waste meeting the same criteria.

(D) If the animal tissue/carcass waste requires commercial disposal, packaging will be as required by the commercial disposal company or by applicable regulations.

(7) The obliteration and/or removal of "Radioactive" signs, symbols, and markings will be accomplished either at the time RSS delivers the radioactive material to the authorized user, or by the user prior to placing the containers into the laboratory dry waste container. Periodic quality control compliance surveys and audits will provide RSS an opportunity to verify compliance. Compliance with 25 TAC §289(fff)(5)(B) will be through the double packaging of waste material.

C.5 Waste Records

(a) The following records will be maintained coincidental to the collection, processing, and disposal of radiological/special waste:

(1) Radioactive Waste Disposal Record (RSS Form A-06)

(2) Radioactive Waste Quality Control Survey (RSS Form A-19)

(3) Waste Disposal Summary Report

(4) Commercial disposal receipts/records

(b) Waste forms may be changed or modified by RSS as necessary, however, the information collected and summaries made will satisfy the requirements of applicable regulations.

(c) Records will be maintained by RSS as specified by applicable regulations or until such time as TDSHS-RC authorizes records disposal.

(d) Following is a brief explanation of each waste form and summary report:

(1) Radioactive Waste Disposal Record

(A) The "Radioactive Waste Disposal Record" (RSS Form A-06) is a carbonless, multi-page form that is provided to the various radioactive material users by RSS. As radioactive/special waste is deposited in the appropriate radioactive/special waste container, appropriate entries are made on the form for each radioactive isotope contained in the waste. Information entered on the form includes the following:

(i) Sublicensee name;

(ii) Department;

(iii) Telephone number;

(iv) Type of waste;

(v) Composition of waste (aqueous, organic, etc.);

(vi) Date of disposal (date waste deposited in container);

(vii) Name of individual depositing waste;

(viii) Laboratory room number;

(ix) Isotope disposed;

(x) Activity per isotope (in activity units specified on the form); and

(xi) Weight or volume of the disposed waste.

(B) The Sublicensee or radiation worker will total the activities and weights or volumes for each isotope listed on the form and record these totals in the appropriate section of the form.

(C) Upon completion of the form, RSS may be notified that the waste container is ready for disposal.

(2) The "Radioactive Waste Quality Control Survey" (RSS Form A-19) form will be used to Document external and internal quality control sampling of waste

packages. All appropriate information identifying the contents of the waste container and the methods used to test the contents will be listed on and/or attached to the form.

(3) The "Special Waste and Animal Carcass Disposal Summary" (RSS Form A-14) will be used to summarize each disposal containing special waste material.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix D Contamination Wipe Surveys

D.1 General

This guidance document has been prepared to develop and improve the prevention and control of the spread of removable radioactive contamination at Texas Tech University Health Sciences Center and all regional campuses. Basic to the control of radioactive contamination is the practice of good personal hygiene, maintenance of a clean and orderly work area, and regular monitoring of work areas to detect the presence of contamination. The individual responsible for contamination monitoring, whether a researcher or radiation safety technician, should perform an aggressive search for radioactive contamination, such that the results of the survey assures, with a high level of certainty, that the area is free from contamination.

D.2 Preparation

(a) Preparation for contamination surveys should be thorough and methodical. The preparation process should include a review of past surveys, identification of the areas of interest, records of radioactive isotopes used, and consideration of any special instruments or equipment necessary for conducting the survey.

(b) Draw or obtain a sketch or map of the area to be surveyed. The sketch or map should indicate radiation use and storage areas, and any special instruments or equipment of concern.

(c) The survey process should be conducted in such a way as to minimize the possible spread of removable contamination as a result of the survey. Contamination wipes should be done in an orderly fashion, beginning in areas with the least potential for contamination and ending in areas with greater potential. The following guidelines should be considered when planning the order of the survey, beginning with the area least likely to be contaminated:

(1) Office areas;

(2) Non-radiation use laboratories/areas;

(3) Low-level counting room(s);

(4) Counting room(s);

(5) Radiation receiving/storage areas;

(6) Radiation work areas; and

(7) Rooms or laboratory areas classified as “hot” labs.

D.3 Survey Guidelines

(a) The surveyor should now be reasonably prepared to enter the area of interest to begin the contamination survey, having formulated a tentative plan of action for the survey process.

(b) Upon arrival at the area of interest, an attempt should be made to interview the radiation worker(s) concerning recent activities involving utilization of radioactive material. The following questions should be considered:

(1) Have sources of radiation been used since the last survey?

(2) What radioactive isotopes, if any, were used?

(3) How were the radioactive sources used?

(4) In what areas were the radioactive sources used?

(5) Have any new or additional sources of radiation been recently acquired?

(6) Has the radiation worker(s) encountered any difficulties or problems of which the surveyor should be aware?

(c) The surveyor finalizes the plan of action by determining a representative sample of the area, which should include the following considerations:

(1) Number of contamination wipes to be taken:

(2) Location of the contamination wipes to be taken (identified on the sketch or map of the area);

(3) Individual work habits of the radiation laboratory workers, determined through the following:

(A) Interview;

(B) Observation;

(C) Personal hygiene; and

(D) Laboratory housekeeping.

(4) Changes or modifications to the work area(s), to include:

(A) Newly identified radiation work area(s);

(B) Newly identified radioactive material storage area(s);

(C) Newly identified radioactive equipment, instruments, or devices; and

(D) Other undocumented use or storage area(s), instruments, or equipment.

(5) Laboratory traffic flow, to include:

(A) Observation of high utilization areas;

(B) Observation of high utilization radiation instruments and equipment; or

(C) Observation of high-traffic corridors and walkways.

(6) Additional Contamination Wipe Survey Considerations

(A) Countertops;

(B) Fume hood aprons and sashes, especially the frame and outside handles and glass;

(C) Radiation sinks;

(D) Sink faucets;

(E) Knobs and handles (doors, valves, freezers, incubators, centrifuges, etc.);

(F) Floor areas in front of radiation work areas, storage areas, sinks, and hoods;

(G) Personal workspace, including computers keyboards, mouse, desks, chairs, drawers, etc.

(H) Horizontal surfaces where the radiation containers may have been placed;

(I) Rings on surfaces where the containers may have been placed.

(J) Walls or other vertical surfaces near the radiation work area(s);

(K) Telephones, especially dials/keypads and handsets;

(L) Refrigerators/freezers, handles, doors, sides, shelving; horizontal surfaces;

(M) Instrument/equipment switches, range selection knobs, function/activation switches.

D.4 Materials and Methods

(a) Contamination wipe media may vary, and may include paper wipes/toweling (such as Kimwipes), filter media, or swabs. Wet contamination wipes (wetted with water or an appropriate organic solvent) may remove more contamination than dry wipes, however, wet wipes may mask some ^{14}C or ^{3}H counts, if using an internal proportional counting system.

(b) Apply moderate pressure with one or two fingers on the back of the wipe media, and rub over the surface to be surveyed. Some individuals prefer to use a No. 8 or 10 rubber stopper to back the wipes. The total area per wipe should be at least 100 cm^2 (approximately 16 in^2).

(c) Contamination wipes may be transported to the counting room in manila paper envelopes, paper or plastic packets, paper or plastic bags, etc. Efforts should made to eliminate or minimize the possibility of cross-contamination among the wipes.

D.5 Evaluation, Contamination Limits, and Action Levels

(a) In evaluating the results of an area survey, the surveyor must keep in mind that contamination can be like an iceberg – the contamination detected may be only a small fraction of the total contamination present. A more extensive survey may immediately be required, and it may be necessary to evaluate possible personnel exposures or additional spread of contamination.

(b) Guidance relating contamination wipe survey results and action levels is provided in the table below:

Type of Area	Satisfactory – No Action Necessary	Warning – Additional Care Necessary	Unsatisfactory – Decontamination Required
Offices, Unrestricted Areas	<MDA*	MDA* – 100 dpm**	>100 dpm**
Radiation Laboratories and Work Areas	<200 dpm**	200 dpm** – 1000 dpm**	>1000 dpm**

*MDA (Minimum Detectable Activity) = $\frac{3\sqrt{Background(dpm)}}{2}$

**dpm (Disintegrations per Minute)/100 cm^2

Notes:

(1) Response levels for alpha emitters are one-tenth of those indicated above;
(2) Response levels for "low-risk" radionuclides (e.g., ^{14}C, ^{3}H, ^{35}S and ^{99m}Tc) may be increased by a factor of ten over those shown above;
(3) Low-risk radionuclides are those with maximum beta energies less than 0.2 MeV, and/or x-ray dose rates less than 1 mSv/hr at 1 meter, with a permissible concentration in air limit greater than 0.037 Bq/ml.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix E
Direct Radiation Surveys

E.1 General

The direct radiation survey will be conducted as a part of each area survey. The survey will be conducted with an appropriately calibrated survey instrument or radiation monitor.

E.2 Preliminary Evaluation

A complete direct radiation survey is very time-consuming, if properly done; therefore, a preliminary evaluation should be performed.

E.3 Materials and Methods

(a) Equipment

(1) A survey instrument with a Geiger-Mueller (GM) or scintillation detector, as appropriate, and with an audible signal, when available, should be used.

(2) When using an ion chamber instrument, the surveyor should stay in each different monitored area from 35 to 60 seconds to obtain accurate results, due to the long time constant of the instrument.

(b) Survey Guidelines

(1) While listening for changes in the rate of the audible output (if available) or changes in the observed rate of exposure, the individual conducting the survey will perform a thorough scan of all survey areas.

(2) Any areas indicating more than 20 cpm above background will be identified on the survey map.

(3) The surveyor will re-survey areas where exposure rates greater than three times background are identified.

(4) Radiation exposure levels found in the vicinity of any radiation source(s) located outside of storage areas will be recorded on the survey map, the radiation source(s) will be placed in proper storage, and the survey will be repeated.

(5) If there are no areas where direct radiation levels exceed three times background, direct radiation levels may be recorded as < 0.1 mR/hr.

(6) If direct radiation levels continue to be elevated after all radioactive sources have been monitored and properly stored, the need for contamination wipe surveys may be indicated.

(7) A general area survey should always be taken. Choose a location or two near the center of an area that is likely to be occupied by personnel, and record the reading(s).

(8) Areas found to have particularly high exposure readings should have contact measurements made, however, precautions must be taken to prevent contamination of the survey instrument. Personnel exposure readings should be taken at all points monitored for high readings. Measurements should be made approximately 18 inches from the location of the highest reading.

E.4 Results and Reporting

(a) Record results in mR/hr on the survey map and place it in the contamination survey files.

(b) For surveys indicating measurements of 2 mR/hr or greater, notify the Radiation Safety Officer (RSO) immediately.

(c) Reports of surveys conducted by the RSO will be filed in the laboratory contamination survey files. The laboratory supervisor or Sublicensee will receive a summary report of the findings of the RSO inspection.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix F

Possible Health Risks to Children of Women Exposed to Ionizing Radiation During Pregnancy

Texas Tech University Health Sciences Center

Possible Health Risks To Children of Women Who Are Exposed to Radiation During Pregnancy

Introduction

Pregnant women (or those who may be attempting to become pregnant) who work in or may visit designated Radiation Areas should be aware of environmental and behavioral risks that could affect the unborn child and the potential biological risks of radiation exposure to the embryo/fetus. The following information is provided to assist in evaluating those risks and deciding what additional action, if any, should be taken to reduce exposure and minimize risk.

Everyone is exposed daily to various kinds of radiation: heat, light, ultraviolet, microwave, ionizing, and so forth. For the purposes of this document, only ionizing radiation (gamma rays, x-rays, alpha particles, beta particles, neutrons, etc.) will be considered.

Background and Other Exposures

Radiation exposure can be internal or external in nature. Terrestrial and cosmic radiation sources expose the body from the outside (external exposure), and the internal sources expose the body from the inside (internal exposure). People are exposed to different amounts of natural "background" ionizing radiation. The table below shows the average annual external dose to individuals due to natural background radiation.

Table 1 – Natural Background Radiation Exposure

RADIATION SOURCE	AVERAGE ANNUAL DOSE
Terrestrial – Radiation from soil and rocks Cosmic – Radiation from outer space Internal – Radioactivity normally found within the human body	97 millirem
Radon	198 millirem
Total natural background exposure	**295 millirem**

The average person is thus exposed to a total average annual dose of about 295 millirem per year from natural background radiation.

In addition to natural background radiation, individuals may be exposed to some man-made sources of radiation. Medical x-rays, nuclear medicine, and even some consumer products are sources of additional radiation exposure. Other sources of exposure may

include occupational exposure, nuclear fallout from weapons testing, and exposure from the nuclear fuel cycle (reactors). The table below shows average annual exposures from man-made and other sources of exposure.

Table 2 – Man-made and Other Sources of Radiation Exposure

RADIATION SOURCE	TYPE OF RADIATION	AVERAGE ANNUAL DOSE
Man-made	Medical x-rays	40 millirem
	Nuclear medicine	14 millirem
	Consumer products	11 millirem
Other	Occupational	1.1 millirem
	Fallout	<1.1 millirem
	Nuclear fuel cycle	0.4 millirem
	Miscellaneous	0.4 millirem
Total Man-made & Other		**68 millirem**

From the information provided in Table 1 and Table 2, the average individual receives a total average annual radiation exposure of approximately 363 millirem per year. This exposure will vary slightly due to geographical location (someone who resides in Colorado, New Mexico, or Wyoming typically receives about fifty percent more exposure than someone living in Texas, Louisiana, or Florida) and whether or not the individual has had medical x-ray or nuclear medicine procedures performed.

Radiation Exposure Limits

The amount of radiation exposure a person receives is called the radiation dose. Dose is commonly measured in millirem (mrem), rem (r), or Sievert (Sv). Maximum allowable exposure limits have been established for radiation workers and the general public.

Ionizing radiation, like many other things taken to excess, can be harmful. A large dose (exposure) to the whole body, such as a 600 rem (6.0 Sv) exposure in one day, would probably cause death. Large doses of this magnitude, however, rarely occur, and are typically the result of large-scale nuclear accidents, such as the Chernobyl reactor accident that occurred in the former Soviet Union in 1986. Similarly, an exposure to relatively low levels of carbon monoxide gas can be deadly.

Control of exposure to radiation is based on the assumption that any exposure, no matter how small, involves some level of risk. Although occupational exposure limits are intentionally set low, medical evidence indicates that no clinically observable injuries to individuals occur due to radiation exposures below established occupational external radiation exposure limits. This also held true for exposures received under

early occupational exposure limits that were many times greater than the current limits. While the risk to individuals who may be exposed at the occupational exposure levels may be considered to be very low, it is not valid to say that the risk is zero.

The current occupational radiation exposure limits were developed and carefully reviewed by nationally and internationally recognized groups of scientists, researchers and health physicists. These limits were originally set for adult workers, and special consideration must be given when the exposed individual is, or may be, a pregnant woman, as the exposure to radiation may also involve the exposure of an unborn child. The exposure limits for dose to an embryo/fetus were established to minimize the risk to the unborn child. Table 3, below, lists the maximum allowable exposure limits for adult workers, the general public, minors (children), and the embryo/fetus.

Table 3 – Maximum Allowable Annual Radiation Dose

EXPOSURE CLASS	ANNUAL DOSE LIMIT
Occupationally-exposed radiation worker	5 rem (0.05 Sv)
Members of the general public	0.5 rem (0.005 Sv)
Minors (under age 18)	0.5 rem (0.005 Sv)
Embryo/fetus (for term of pregnancy)	0.5 rem (0.005 Sv)

Biological Effects of Radiation Exposure

Ionizing radiation produces damage while penetrating body tissues primarily by ejecting electrons from the atoms comprising tissues. This phenomenon is known as ionization. Destructive radiation interaction at the atomic level results in molecular change, and this in turn can cause cellular damage leading to abnormal cell function or complete loss of cell function. If excessive cellular damage occurs, the living organism exhibits genetic or other changes such as mutations, cataracts, leukemia, or changes in blood count. Table 4 provides some basic information on the known biological effects of various levels of radiation exposure.

Because the potential of radiation exposure to cause biological damage exists, the use of ionizing radiation should be limited or controlled whenever possible. Unnecessary exposures should be eliminated, and all other exposures should be kept *as low as reasonably achievable* (ALARA).

Pregnancy and Occupational Radiation Exposure

Any individual who is routinely exposed to radiation sources in the normal performance of the job is classified as an occupationally exposed individual. In the hospital setting, these individuals include radiologists, radiographers, nuclear medicine technologists, radiation therapy technologists, and may include nurses who care for

Table 4 – Radiation Dose and Biological Effects

RADIATION DOSE	BIOLOGICAL EFFECT
25 rem (0.25 Sv)	Blood changes (e.g. measurable hematological depression, decreases in the number of lymphocytes present in the circulating blood
150 rem (1.5 Sv)	Nausea, diarrhea
200 to 600 rem (2.0 to 6.0 Sv)	Erythema (diffuse redness over an area of skin after irradiation)
250 rem (2.5 Sv)	If dose is to gonads, temporary sterility
300 rem (3.0 Sv)	50% chance of death; lethal dose for 50% of population over 30 days (LD 50/30)
600 rem (6.0 Sv)	Death

brachytherapy patients or work as surgical technicians. In the academic setting, occupationally exposed workers include research personnel who work with radioactive materials or x-ray devices. In most cases, depending upon the type of radiation used, these individuals will be assigned radiation dosimetry devices to monitor radiation exposure.

Radiation dosimetry devices are processed and read at specific time intervals (usually monthly or quarterly), and the readings are reviewed by the institutional Radiation Safety Officer (RSO) to assure that no worker receives a radiation dose in excess of the maximum permissible doses allowed by regulations. A copy of the radiation exposure report is available from the Radiation Safety Officer for your review, comments, and questions.

For pregnant or potentially pregnant women, the National Council on Radiation Protection and Measurement (NCRP) makes two important points on its specific recommendations on dose limits to these individuals:

1. The maximum permissible dose to an embryo/fetus of 0.5 rem (5 mSv) refers to the radiation dose received by the embryo/fetus during the gestation period, *not the radiation dose to the mother*. The radiation dose, as indicated on the mother's dosimetry monitoring device, may or may not correspond to the approximate fetal dose which would depend upon the type and energy of the radiation to which the mother is exposed during the performance of her work.

2. The NCRP, in making its 0.5 rem (5 mSv) dose recommendation, considers the embryo and fetus as "an involuntary visitor brought into a radiation area" as a result of the mother being an occupationally exposed individual.

Radiation and the Developing Fetus

It has been known since 1906 that cells which are dividing very rapidly and are undifferentiated in their structure and function are generally more sensitive to radiation. In the embryo stage, cells meet both these criteria and thus would be expected to be highly sensitive to radiation. Furthermore, there is direct evidence that the embryo/fetus is radiosensitive, especially to certain radiation effects during certain periods after conception, particularly during the first 2 to 3 months after conception when a woman may not be aware that she is pregnant.

The U.S. Nuclear Regulatory Commission (USNRC) has indicated that its regulations and recommendations are based upon a conservative assumption that any amount of radiation, regardless of how small, carries the potential for biological harm. Studies indicate, however, that many factors play a role in predicting the potential for biological harm as a result of radiation exposure. Some of these factors include:

1. *Radiation Dose* – In general, the higher the radiation dose, the greater the chances that biological damage will result. For occupationally exposed individuals, this is the basis for keeping one's radiation exposure *as low as reasonably achievable* (ALARA). The exact biological effect becomes much more difficult to predict when radiation doses are low (i.e., less than 5 rem or 50 mSv). This is because more individual exposure histories must be documented to distinguish radiation related injuries from similarly matched control groups who received only general population exposures.

2. *Type of Radiation Exposure* – There are various types of radiation (e.g., x-rays or gamma rays, alpha particles, beta particles, neutrons, etc.), each resulting in varying degrees and types of biological damage.

3. *Energy of the Radiation* – Generally speaking, the penetrating ability of radiation is greatly determined by its energy – the greater the energy, the more penetrating the radiation. This aspect is especially important in assessing the radiation dose delivered to a fetus as a result of radiation exposure to the mother. For example, if the mother is exposed to high energy (i.e., more penetrating) x-rays, the radiation dose to the mother may well approximate the dose to the fetus. On the other hand, this may not be the case with lower energy x-rays.

4. *Part of the Body Exposed to the Radiation* – All parts of the body are not equally sensitive to the effects of radiation. It is for this reason that maximum permissible doses (MPD) are different for the hands, the whole body, the skin, etc. The fetus, which is especially sensitive to the effects of radiation, is also assigned an individual MPD of 0.5 rem (5 mSv) during the gestation period.

5. *Internal vs. External Radiation Exposure* – Inhalation, ingestion, or absorption may lead to incorporation of radioactivity within the developing embryo or fetus and must be avoided.

Radiation and the Potentially Pregnant Worker

As mentioned previously, studies in radiation biology have shown that cells which are actively dividing and are in early stages of development tend to be very sensitive to radiation. All individuals have cells within the body that fit this general description, such as stem cells of the bone marrow and GI tract, and certain reproductive cells. The potentially pregnant radiation worker, however, also has an additional group of radiosensitive cells – the developing fetus. It is for this reason that this information is provided, so that additional appropriate precautions may be taken during the pregnancy period.

Considerable information has been gathered and studied regarding *in utero* effects of radiation on humans. Studies indicate that radiation effects on a developing fetus depend upon a number of variables. To assess any potential risks to the fetus, the individual must answer the following questions:

1. What was the dose delivered to the fetus? (Note: This may or may not be the same as the dose to the mother, depending upon the type and energy of the radiation.)

2. During what stage of fetal development was the dose delivered (first, second, or third trimester)?

3. Was the fetal dose delivered uniformly over time?

4. What type of radiation delivered the dose (e.g., 250 keV x-rays, 662 keV gamma rays, 1 MeV neutrons, etc.)?

5. Was the dose delivered to the fetus the result of external exposure to the mother or internal deposition of a radionuclide?

Some of these questions may be somewhat difficult to answer, especially in the early stages of pregnancy, when the worker may not even realize that she is indeed pregnant. Most institutions or individual departments (e.g., radiology, nuclear medicine, radiation oncology, etc.) have specific policies to assure the safety of pregnant workers.

It is, therefore, important that as a radiation worker, individuals notify a supervisor and/or the Radiation Safety Officer as soon as pregnancy is suspected or confirmed.

All employees who receive 100 mrem or more per month (whole body dose) and who are considering pregnancy should be particularly aware of all gonadal exposures and use all appropriate precautions to minimize exposures. This is recommended to employees such that an exposure in excess of the regulatory limit (0.5 rem or 500 mrem), prior to receipt of personnel dosimetry reports, is greatly reduced.

Radiation sources are used in many forms such as x-ray machines, sealed sources, therapy units, radiolabeled compounds, etc., with each representing a different degree of relative radiation hazard. Early notification to the supervisor and/or RSO of an individual's suspected pregnancy is important in evaluating the relative risk to the worker and her unborn child. Depending upon the relative radiation hazard, policies will vary from no change in normal work habits to reassignment to less hazardous work areas. In many cases, continued application of sound radiological health practices will result in minimal risk to mother and child.

Evaluating the Risk Associated with Radiation Exposure

For radiation workers within the United States, employers abide by guidelines and regulations established and enforced by the U.S. Nuclear Regulatory Commission (USNRC). In more than half of the states, Texas included, enforcement is supervised by the State Health Department. Maximum permissible doses (MPD) established for radiation workers have been recommended by the National Council on Radiation Protection and Measurements (NCRP) based upon studies and current information available on the effects of radiation on human populations.

It is important to realize that the effects of low level radiation exposure (e.g., less than or equal to 5 rad or 50 mGy), much like that encountered by the typical medical facility radiation worker, is most difficult to accurately assess, not only in regards to the individual worker, but also to the developing fetus. One of the primary reasons for this uncertainty is the fact that there are many factors within an individual's own environment (e.g., air pollution, pesticides in the food supply, food additives, etc.) and of an individual's own lifestyle (e.g.. tobacco use, alcohol use, lack of adequate exercise, stress, etc.), which could also result in the same effects. Some of these effects on a developing fetus and the relative risk of occurrence are shown in Table 5.

The data indicate that there are many types of birth defects that can and do occur naturally – almost all of these occurring with greater chance than birth defects associated with *in utero* low level (less than 1 rad or 10 mGy) radiation exposure. With whole body MPD for radiation workers set at 5 rem and MPD to the developing fetus set at 0.5 rem during the gestation period, if employers and employees work toward keeping occupational exposures *as low as reasonably achievable* (ALARA) and below regulatory limits, the probability that there would be any effect on the fetus as a result of occupational radiation exposure would be extremely low (see Table 6).

Table 5 – Potential Pregnancy Risk Factors

RISK FACTOR	POTENTIAL EFFECTS ON THE PREGNANCY	RELATIVE RISK
Maternal Cigarette Use:		
• Less than one pack/day	Infant death	1 in 5
• More than one pack/day	Infant death	1 in 3
Maternal Alcohol Consumption:		
• 2 - 4 drinks/day	Signs of fetal alcohol syndrome (growth defects, brain dysfunctions, etc.)	1 in 5
• More than 4 drinks/day		1 in 3 to 1 in 2
• Chronic alcohol (more than 10 drinks/day)		350 in 1000
Maternal Age:		
• 20 years	Down's Syndrome (mental retardation and growth defects)	1 in 2300
• 35 – 39 years		1 in 64
• Unknown	Developmental Anomaly (natural incidence)	2 to 4 in 100 live births
• Unknown	Chromosomal Abnormalities (natural incidence)	~ 1 in 200
• Unknown	Major Malformation at Time of Delivery	28 in 1000
• Unknown	Spontaneous Abortion During Pregnancy	30 to 50 in 100
Embryo or Fetal Irradiation:		
• Childhood Cancer		
1 rem	Childhood Leukemia Deaths Before Age 12	1 in 3333
1 rem	Death from Other Childhood Cancers Before Age 10	1 in 3571

The risk to the individual is low, but the total impact to the population of all radiation workers demands that the total dose be maintained *as low as reasonably achievable* (ALARA).

It is not only the employer's responsibility to assure a safe working environment, but also the responsibility of the employee to use safe working habits and common principles of radiation protection to minimize radiation exposure. There must be close cooperation between employer and employee to minimize radiation dose to the fetus.

Table 6 – Probability of Birthing Healthy Children After Varying Degrees of Low Level Radiation Doses

DOSE TO CONCEPTUS	PROBABILITY OF NO MALFORMATION	PROBABILITY CHILD WILL NOT HAVE MALFORMATION OR DEVELOP CANCER
Mrem (mSv)	%	%
0 (0)	96	95.93
50 (0.5)	95.999	95.928
100 (1.0)	95.998	95.922
250 (2.5)	95.995	95.91
500 (5.0)	95.99	95.88
1000 (10.0)	95.98	95.83

Declaration of Pregnancy

It is important that women who are pregnant or may become pregnant notify the Radiation Safety Officer as soon as possible so that radiation exposures can be eliminated or minimized. While a formal declaration of pregnancy is voluntary, it is recommended that any individual who is or thinks she may be pregnant, formally declare her pregnancy to the Radiation Safety Officer so that appropriate radiation exposure monitoring of the developing embryo/fetus may begin.

What Can be Done to Reduce Radiation Dose to the Fetus if I Wish to Continue to Work?

1. Notify your supervisor or the Radiation Safety Officer as soon as you know or even suspect that you might be pregnant. Most departments have specific policies regarding pregnant radiation workers.

2. Do not work alone where there exists the potential for high radiation exposure or equipment that produces high radiation exposure rates in the case of radiation emergency situations, such as with cobalt therapy units, brachytherapy radiation sources, fluoroscopic units, etc.

3. Do not perform radioiodination procedures or work with unsealed sources of radioactive iodine.

4. Even when working with low radiation sources, always wear your assigned dosimetry monitoring device, including the fetal monitoring device, if supplied.

5. Practice the basic principles of reducing radiation exposure, which includes the following:

    - **TIME –** Reduce your time spent in the vicinity of radiation sources.

    - **DISTANCE –** The greater the distance between you and the source of radiation, the less radiation exposure you will receive.

    - **SHIELDING –** Use appropriate shielding wherever possible and practical. You should consult with your supervisor and/or the Radiation Safety Officer to determine if wearing a protective lead apron would be helpful in reducing radiation exposure.

Summary and Conclusion

It is your responsibility as a radiation worker to decide whether your occupational exposure is sufficiently low so as to not adversely affect your unborn child. If you have questions or are unsure of what choices or action to take, contact the Radiation Safety Officer for advice and consultation. Following is a list of possible alternatives you may consider while making your decision:

- If you are now pregnant or expect to be pregnant, you could decide not to accept or continue assignments in radiation work areas.

- You could reduce your exposure, where possible, by decreasing the amount of time you spend in the radiation area, increasing your distance from the radiation source, and by using appropriate shielding.

- If you become pregnant, you could ask your supervisor to reassign you to areas involving less exposure to radiation.

- You could delay having children until you are no longer working in an area where the radiation dose to your unborn baby could exceed 0.5 rem.

- You may also choose to continue working in the higher radiation areas, however, with full awareness that you are doing so at some slightly increased risk to your unborn child.

You may also consider the following facts to help you make a decision concerning radiation exposure and pregnancy:

- The first three months of pregnancy are when the developing embryo is most radiosensitive and, therefore, more likely to be affected by radiation exposure.

From a radiological standpoint, you should make your decision quickly, once it is determined that you are pregnant.

- In most cases of occupational exposure, the actual dose received by the unborn child may be less than that of the mother, due to the fact that the mother's body may absorb some radiation.

- At present occupational exposure limits, the actual risk to the unborn child is small, however, experts disagree on the exact amount of risk.

- There is typically no need for concern about sterility or loss of your ability to bear children. The radiation dose required to produce such effects is about 70 times greater than the dose limit for adult women, and about 100 times greater for adult males.

Additional Information

If you have questions or concerns about, or do not understand the above information and its impact on you and/or your developing child, please contact:

Radiation Safety Services
TTU Health Sciences Center
3601 4th Street, STOP 9020
Lubbock, TX 79430-9020

806-743-2597
806-743-2597 (fax)

Appendix: Questions And Answers Concerning Prenatal Radiation Exposure

(1) Why am I receiving this information?

USNRC and TDH-BRC regulations require that licensees instruct individuals working with licensed radioactive material in radiation protection as appropriate for the situation. The instruction below describes information that occupational workers and their supervisors should know about the radiation exposure of the embryo/fetus of pregnant women.

The regulations allow a pregnant woman to decide whether she wants to formally declare her pregnancy to take advantage of lower dose limits for the embryo/fetus. This instruction provides information to help women make an informed decision whether to declare a pregnancy.

(2) If I become pregnant, am I required to declare my pregnancy?

No. The choice whether to declare your pregnancy is completely voluntary. If you choose to declare your pregnancy, you must do so in writing and a lower radiation dose limit will apply to your embryo/fetus. If you choose not to declare your pregnancy, you and your embryo/fetus will continue to be subject to the same radiation dose limits that apply to other occupational workers.

(3) If I declare my pregnancy in writing, what happens?

If you choose to declare your pregnancy in writing, the licensee must take measures to limit the dose to your embryo/fetus to 0.5 rem (5 millisievert) during the entire pregnancy. This is one-tenth of the dose that an occupational worker may receive in a year. If you have already received a dose exceeding 0.5 rem (5 mSv) in the period between conception and the declaration of your pregnancy, an additional dose of 0.05 rem (0.5 mSv) is allowed during the remainder of the pregnancy. In addition, USNRC and TDH-BRC regulations require licensees to make efforts to avoid substantial variation above a uniform monthly dose rate so that all the 0.5 rem (5 mSv) allowed dose does not occur in a short period during the pregnancy.

This may mean that, if you declare your pregnancy, the licensee may not permit you to do some of your normal job functions if those functions would have allowed you to receive more than 0.5 rem, and you may not be able to have some emergency response responsibilities.

(4) Why do the regulations have a lower dose limit for the embryo/fetus of declared pregnant woman than for a pregnant worker who has not declared?

A lower dose limit for the embryo/fetus of a declared pregnant woman is based on a consideration of greater sensitivity to radiation of the embryo/fetus and the involuntary nature of the exposure. Several scientific advisory groups have recommended that the dose to the embryo/fetus be limited to a fraction of the occupational dose limit.

(5) What are the potentially harmful effects of radiation exposure to my embryo/fetus?

The occurrence and severity of health effects caused by ionizing radiation are dependent upon the type and total dose of radiation received, as well as the time period over which the exposure was received. The main concern is embryo/fetal susceptibility to the harmful effects of radiation such as cancer.

(6) Are there any risks of genetic defects?

Although radiation injury has been induced experimentally in rodents and insects, and in the experiments was transmitted and became manifest as hereditary disorders in their offspring, radiation has not been identified as a cause of such effect in humans. Therefore, the risk of genetic effects attributable to radiation exposure is speculative. For example, no genetic effects have been documented in any of the Japanese atomic bomb survivors, their children, or their grandchildren.

(7) What if I decide that I do not want any radiation exposure at all during my pregnancy?

You may ask your employer for a job that does not involve any exposure at all to occupational radiation dose, but your employer is not obligated to provide you with a job involving no radiation exposure. Even if you receive no occupational exposure at all, your embryo/fetus will receive some radiation dose [on average 75 mrem (0.75 mSv)] during your pregnancy from natural background radiation.

The USNRC has reviewed the available scientific literature and concluded that the 0.5 rem (5 mSv) limit provides an adequate margin of protection for the embryo/fetus. This dose limit reflects the desire to limit the total lifetime risk of leukemia and other cancers. If this dose limit is exceeded, the total lifetime risk of cancer to the embryo/fetus may increase incrementally. However, the decision on what level of risk to accept is yours.

(8) What effect will formally declaring my pregnancy have on my job status?

Only the licensee can tell you what effect a written declaration of pregnancy will have on your job status. As part of your radiation safety training, the licensee should tell you the company's policies with respect to the job status of declared pregnant women. In addition, before you declare your pregnancy, you may want to talk to your supervisor or your radiation safety officer and ask what a declaration of pregnancy would mean specifically for you and your job status.

In many cases you can continue in your present job with no change and still meet the dose limit for the embryo/fetus. For example, most commercial power reactor workers (approximately 93%) receive, in 12 months, occupational radiation doses that are less than 0.5 rem (5 mSv). The licensee may also consider the likelihood of increased radiation exposures from accidents and abnormal events before making a decision to allow you to continue in your present job.

If your current work might cause the dose to your embryo/fetus to exceed 0.5 rem (5 mSv), the licensee has various options. It is possible that the licensee can and will make a reasonable accommodation that will allow you to continue performing your current job, for example, by having another qualified employee do a small part of the job that accounts for some of your radiation exposure.

(9) What information must I provide in my written declaration of pregnancy?

You should provide, in writing, your name, a declaration that you are pregnant, the estimated date of conception (only the month and year need be given), and the date that you give the letter to the licensee. A form letter that you can use is included at the end of these questions and answers. You may use that letter, use a form letter the licensee has provided to you, or write your own letter.

(10) To declare my pregnancy, do I have to have documented medical proof that I am pregnant?

USNRC and TDH-BRC regulations do not require that you provide medical proof of your pregnancy. However, regulations do not preclude the licensee from requesting medical documentation of your pregnancy, especially if a change in your duties is necessary in order to comply with the 0.5 rem (5 mSv) dose limit.

(11) Can I tell the licensee orally rather than in writing that I am pregnant?

No. The regulations require that the declaration must be in writing.

(12) If I have not declared my pregnancy in writing, but the licensee suspects that I am pregnant, do the lower dose limits apply?

No. The lower dose limits for pregnant women apply only if you have declared your pregnancy in writing. The United States Supreme Court has ruled (in *United Automobile Workers International Union v. Johnson Controls, Inc*., 1991) that "Decisions about the welfare of future children must be left to the parents who conceive, bear, support, and raise them rather than to the employers who hire those parents." The Supreme Court also ruled that your employer may not restrict you from a specific job "because of concerns about the next generation." Thus, the lower limits apply only if you choose to declare your pregnancy in writing.

(13) If I am planning to become pregnant but am not yet pregnant and I inform the licensee of that in writing, do the lower dose limits apply?

No. The requirement for lower limits applies only if you declare in writing that you are already pregnant.

(14) What if I have a miscarriage or find out that I am not pregnant?

If you have declared your pregnancy in writing, you should promptly inform the licensee in writing that you are no longer pregnant. However, if you have not formally declared your pregnancy in writing, you need not inform the licensee of your non-pregnant status.

(15) How long is the lower dose limit in effect?

The dose to the embryo/fetus must be limited until you withdraw your declaration in writing or you inform the licensee in writing that you are no longer pregnant. If the declaration is not withdrawn, the written declaration may be considered expired one year after submission.

(16) If I have declared my pregnancy in writing, can I revoke my declaration of pregnancy even if I am still pregnant?

Yes, you may. The choice is entirely yours. If you revoke your declaration of pregnancy, the lower dose limit for the embryo/fetus no longer applies.

(17) What if I work under contract at a licensed facility?

The regulations state that you should formally declare your pregnancy to the licensee in writing. The licensee has the responsibility to limit the dose to the embryo/fetus.

References

National Council on Radiation Protection and Measurements, *Considerations Regarding the Unintended Radiation Exposure of the Embryo, Fetus, or Nursing Child*, NCRP Commentary No. 9, Bethesda, MD, 1994.

National Council on Radiation Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, Bethesda, MD, 1993.

National Council on Radiation Protection and Measurements, *Risk Estimates for Radiation Protection*, NCRP Report No. 115, Bethesda, MD, 1993.

National Institutes of Health (2003). *Radiation Safety Guide.* http://www.niehs.nih.gov/odhsb/radhyg/radguide/home.htm.

Pizzarello, D. J., and R. L. Witcofski. 1982. *Medical Radiation Biology, Second Edition.* Philadelphia, PA: Lea & Febiger.

Shapiro, J. 1990. *Radiation Protection: A Guide for Scientists and Physicians, Third Edition.* Cambridge, MA: Harvard University Press.

Shleien, B., and M. S. Terpilak, ed. 1984. *The Health Physics and Radiological Health Handbook.* Olney, MD: Nucleon Lectern Associates, Inc.

U.S. Nuclear Regulatory Commission, "Instruction Concerning Prenatal Radiation Exposure," Regulatory Guide 8.13, Revision 3, June 1999.

U.S. Nuclear Regulatory Commission, "Instruction Concerning Risks from Occupational Radiation Exposure," Regulatory Guide 8.29, Revision 1, February 1996.

U.S. Nuclear Regulatory Commission, "Radiation Dose to the Embryo/Fetus," Regulatory Guide 8.36, July 1992.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix G
X-Ray Control Program

G.1 General

The Texas Tech University Health Sciences Center (TTUHSC) X-Ray Control Program is under the supervision of the TTUHSC Radiation Safety Officer (RSO). The X-Ray Control Program has been established to ensure that x-ray-producing machines, equipment, and devices are operated safely, TTUHSC personnel and the general public are protected from unnecessary exposure to ionizing radiation, and equipment and procedures meet performance standards and operating procedures established by applicable federal, state, and local regulations. Every reasonable effort should be made to maintain radiation exposures As Low As Reasonably Achievable (ALARA).

G.2 Credentialing Requirements

Individuals who operate x-ray-producing machines, equipment, or devices for human use shall meet the appropriate credentialing requirements of rules issued in accordance with the Medical Radiologic Technologist Act, Texas Occupations Code, Chapter 601. Copies of the credentialing document(s) shall be maintained at the location(s) where the individual is working.

G.3 Personnel Dosimetry

(a) Personnel utilizing x-ray-producing machines, equipment, or devices as part of their occupation will be provided with appropriate personnel dosimetry devices as required by applicable regulations.

(b) Dosimetry devices must be worn at the unshielded location of the whole body likely to receive the highest exposure. When wearing a protective apron, the dosimetry device location is typically at the neck or collar.

(c) Additional dosimetry devices used for monitoring the dose to the embryo/fetus of a declared pregnant woman must be located at the waist under any protective apron being worn by the woman.

(d) Willful exposure to excessive amounts of ionizing radiation may lead to disciplinary action.

(e) Occupational dose limits as prescribed in applicable regulations will be observed.

(f) Dosimetry devices not being worn and any control device(s) will be stored in an area away from rooms where radiation machines are in use.

G.4 Operational Guidelines

(a) Only individuals necessary for the radiographic procedure should be in the radiographic room during an exposure.

(b) Personnel shall be equipped with appropriate personal protection devices and/or shielding. The presence of other persons (such as a radiation worker, parent, or guardian) may be required to assist in obtaining cooperation from a patient (in the case of small children) or assist with positioning of the patient. Such individuals shall be provided and wear a lead-lined apron and lead-lined gloves if the individual is assisting in the positioning of the patient.

(c) If any employee is pregnant or becomes pregnant, she may voluntarily inform the RSO in writing of the pregnancy. If the RSO is informed of the pregnancy, the facility must ensure that the dose to the embryo/fetus does not exceed 0.5 rem (500 mrem) during the entire pregnancy.

(d) Protective devices shall be checked annually for defects such as holes, cracks, or tears. This check can be done by visually inspecting or feeling the protective devices, or may also be done by x-raying these items. A record of these checks will be maintained at each x-ray location. If a defect is found at the time of the annual check or on any other occasion, notify the RSO and remove the device from service until it can be repaired or replaced.

(e) If fluoroscopic procedures are being performed, personal protective devices (shields, aprons, gloves, etc.) shall be in place.

(f) All radiographic rooms and areas containing x-ray control consoles are considered to be "Restricted Areas." Access to restricted areas should be controlled to limit access and protect individuals from unnecessary exposure to radiation. The operator of the x-ray device within the area must maintain the restriction.

(g) Only licensed physicians, practitioners, podiatrists, or dentists may order radiographic films or retakes.

(h) Use of a technique chart aids in reducing the exposure to the operator and patient and must be used for all exposures. Technique charts should be displayed in the vicinity of the control panel of each x-ray machine.

(i) X-ray exposure switches shall be of the "dead man" type.

(j) The useful x-ray beam shall be limited to the area of clinical interest.

(k) During the use of fluoroscopic machines, the 5-minute cumulative timing device shall be reset before each fluoroscopic procedure.

(l) The operator must be able to continuously view and communicate with the patient.

(m) During exposures, the operator must be positioned so that operator exposure is ALARA, otherwise, a lead apron, gloves, or other shielding must protect the operator.

(n) When a patient must be held for radiography, mechanical supporting or restraining devices should be used when possible. If an individual must hold the patient, that individual shall be protected with appropriate shielding devices such as protective gloves, aprons, or portable shields, and shall be positioned such that no part of the individual's body will be in the useful beam.

(o) Gonadal shields should be used on all patients unless such devices interfere with the objectives of the radiographic examination.

(p) An individual shall not hold the x-ray tube housing during any radiographic exposure.

(q) Radiation surveys, calibration of x-ray producing machines, equipment, and devices, and other quality assurance measures will be performed as prescribed by applicable federal, state, and local regulations. Radiation Safety Services (RSS) will maintain results of any tests, calibrations, or repairs.

(r) Notices, instructions, and reports to workers shall be posted as required by applicable regulations.

(s) Copies of applicable regulations are available for any user of ionizing radiation at TTUHSC. All persons using x-ray-producing machines, equipment, or devices should become familiar with applicable regulations for the use and control of x-ray radiation.

G.5 Additional Information

Contact the RSO or consult the site-specific Operating and Emergency Procedures for additional information.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix H
Bioassay Guidelines

H.1 General

The Texas Tech University Health Sciences Center (TTUHSC) Bioassay Program is under the supervision of the TTUHSC Radiation Safety Officer (RSO). The Bioassay Program has been established to ensure that TTUHSC personnel are protected from unnecessary exposure to ionizing radiation, and that practices and procedures meet the standards established by applicable federal, state, and local regulations. Every reasonable effort should be made to maintain radiation exposures As Low As Reasonably Achievable (ALARA).

H.2 Bioassay Guidelines

(a) Radiation Safety Services (RSS), with the assistance of the Sublicensees, will identify the radiation laboratory personnel required to participate in the Bioassay Program.

(b) RSS will make arrangements with the appropriate department/agency to provide thyroid bioassay monitoring or to collect urinary excretions for tritium bioassay, as applicable. RSS will schedule appointments for affected personnel, and will then notify affected personnel of the appointment date, time, and location.

(c) RSS personnel will accompany affected personnel on the initial appointment and on any subsequent appointments deemed necessary by the Radiation Safety Officer (RSO).

(d) Thyroid Bioassay – ^{125}I and ^{131}I

(1) RSS will use the "Bioassay Record" (RSS Form A-09T) form for recording information collected during the thyroid bioassay scan and calculating the thyroid burden.

(2) Results of the thyroid bioassay will be used to determine any additional actions that may be necessary.

(e) Tritium Bioassay – ^{3}H

(1) RSS will use the "Bioassay Record" (RSS Form A-09G) form for recording information collected during the tritium bioassay and calculating the urinary excretion concentration.

(2) Results of the tritium bioassay will be used to determine any additional actions that may be necessary.

H.3 Reporting

(a) The RSO or RSS personnel will notify the individual of the bioassay results and any additional actions to be taken.

(b) Records of bioassay surveys will be maintained as required by applicable regulations.

(c) In instances where notification of regulatory agencies is required, the RSO will notify such agencies as required by applicable federal, state, and local regulations.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix I
Common Radioisotopes: Properties and Special Handling Guidelines

I.1 General

(a) Research activities at Texas Tech University Health Sciences Center (TTUHSC) often require the use of radioactive isotopes. Following are basic properties and special handling guidelines for the radioisotopes most commonly used in the research laboratory. For additional information or for information on isotopes not listed, contact Radiation Safety Services (RSS) or the isotope vendor.

(b) Handling precautions and guidelines for all radioisotopes:

(1) Designate handling area(s) and clearly label all containers;

(2) Prohibit eating, drinking, smoking, and mouth pipeting where radioactive isotopes are handled;

(3) Use transfer pipettes, spill trays, and absorbent coverings to confine contamination;

(4) Handle radioisotope compounds that are potentially volatile or in powder form within well-ventilated enclosures;

(5) Wear disposable lab coats, gloves, and other personal protective equipment for secondary protection;

(6) Select gloves appropriate for chemicals handled;

(7) Maintain contamination control by regularly monitoring and promptly decontaminating gloves and surfaces;

(8) Use appropriate radiation detection instrumentation;

(9) Isolate waste in clearly labeled containers according to approved guidelines;

(10) On completing an operation, secure all radioisotopes, remove and dispose of protective clothing and coverings, monitor and decontaminate self and surfaces, wash hands and monitor them again.

I.2 Common Radioisotopes

The following pages contain general information about commonly used radioactive isotopes. Additional information may be obtained from RSS.

Calcium-45 (^{45}Ca)

- Half-life: 163 days
- Biological Half-life: $1.8E^4$ days (bone)
- Radiation: β^- – 0.257 MeV (moderate energy beta)
  No gamma (γ)
  E – 0.257 MeV
- Secondary Radiation: Bremsstrahlung (x-ray) significant at Ci levels
- Maximum Range in Air: Betas – 50 cm (19.7 in)
- Occupational Limits: ALI for oral ingestion: 2 mCi (74 MBq)
  ALI for inhalation: 800 µCi (30 MBq)
- Biological Monitoring: Urine samples
- Shielding: 1 cm Plexiglas
- Detection: Pancake (eff. appx. 0.09 cpm/dpm @ 0.25 in) or end-window GM detectors; liquid scintillation counters (eff. appx. 0.80 cpm/dpm)
- Special Considerations: Millicurie (37MBq) quantities of ^{45}Ca do not present a significant external exposure hazard because the low-energy betas emitted barely penetrate gloves and the outer layer of dead skin. Uptakes of ^{45}Ca are mostly deposited in bone and retained with a long biological half-life ($1.8E^4$ days). Initially eliminated via the urine, however, eventually about half the radioisotope is eliminated via the feces.

Carbon-14 (^{14}C)

- Half-life: 5730 years
- Biological Half-life: Up to 40 days (whole body)
- Radiation: β^- – 0.156 MeV (low energy beta)
  No gamma (γ)
  E – 0.156 MeV
- Secondary Radiation: Bremsstrahlung (x-ray) significant at Ci levels
- Maximum Range in Air: Betas – 22 cm (8.6 in)
- Occupational Limits: ALI: 2 mCi (74 MBq)
- Biological Monitoring: Urine samples or breath measurements $[^{14}C]O_2$
- Shielding: 1 cm Plexiglas
- Detection: Thin window pancake (eff. appx. 0.05 cpm/dpm @ 0.25 in) or thin end-window GM detectors; liquid scintillation counters (eff. appx. 0.10 to 0.70 cpm/dpm)
- Special Considerations: Millicurie (37MBq) quantities of ^{14}C do not present a significant external exposure hazard because the low-energy betas emitted barely penetrate gloves and the outer layer of dead skin. Uptakes of ^{14}C may be assumed to be uniformly distributed throughout all organs and tissues in the body. Some ^{14}C labeled compounds are readily absorbed through the skin and may penetrate gloves. Most ^{14}C labeled compounds are rapidly metabolized and the radioisotope is exhaled as $^{14}CO_2$. Biological half-lives vary from a few minutes up to 40 days. Some compounds and metabolites eliminated via the urine.

Chlorine-36 (^{36}Cl)

- Half-life: $3.01E^5$ years
- Biological Half-life: 10 days (whole body)
- Radiation: EC
  β^- – 0.710 MeV (~98% of decay)
  E 0.710 MeV
- Maximum Range in Air: Betas – 2 m (7 ft)
- Occupational Limits: ALI for oral ingestion: 2 mCi (74 MBq)
  ALI for inhalation: 200 µCi (7.4 MBq)
- Biological Monitoring: Urine samples
- Shielding: 1 cm Plexiglas
- Detection: Thin window pancake or thin end-window GM detectors; liquid scintillation counters
- Special Considerations: Beta emission from ^{36}Cl may present an external hazard to the skin and eyes. ^{36}Cl is almost completely absorbed upon ingestion, and quickly moves from the gastrointestinal tract to the bloodstream. Uptake of ^{36}Cl may be assumed to be uniformly distributed throughout all organs and tissues in the body, and has a biological half-life of 10 days.

Chromium-51 (^{51}Cr)

- Half-life: 27.7 days
- Biological Half-life: 0.5 to $1.0E^{3}$ days depending on chemical form
- Radiation: γ – 0.320 MeV (9.8%of decay)
  X-ray – 0.005 MeV (22.3% of decay)
  Auger Electron – 0.004 MeV (66.9% of decay)
  E – 0.752
- Exposure Rate: 0.18 R/hr at 1 cm from a 1 mCi point source (unshielded)
- Occupational Limits: ALI for oral ingestion: 40 mCi (1.5 GBq)
  ALI for inhalation: 20 mCi (740 MBq)
- Biological Monitoring: Urine samples
- Shielding: 2 mm lead; 21 mm steel (first half-value layer)
- Detection: Thin window pancake or thin end-window GM detectors; scintillation detectors; liquid scintillation counters; gamma scintillation counters
- Special Considerations: Gamma emission from ^{51}Cr presents an external dose hazard. Retention in the body is very dependent on chemical form. Biological half-life can range from 0.5 days up to 1000 days, depending on the compound or chemical.

Indium-111 (^{111}In)

- Half-life: 2.83 days
- Biological Half-life: Indium is assumed to be retained indefinitely, however, the committed dose is significantly reduced due to the short physical half-life of ^{111}In
- Radiation: EC
  γ – 0.171 to 0.245 MeV
  X-ray – 0.023 to 0.026 MeV
  Electron – 0.145 to 0.219 MeV
  Auger Electron – 0.003 to 0.019 MeV
  E – 0.85
- Exposure Rate: 3.2 R/hr at 1 cm from a 1 mCi point source (unshielded)
- Occupational Limits: ALI for oral ingestion: 4 mCi (150 MBq)
  ALI for inhalation: 6 mCi (220 MBq)
- Biological Monitoring: Urine samples
- Shielding: 0.22 mm (0.01 in) lead (first half-value layer)
- Detection: Thin window pancake or thin end-window GM detectors; scintillation detectors; liquid scintillation counters; gamma scintillation counters
- Special Considerations: ^{111}In presents an external radiation exposure hazard. ^{111}In uptakes translocate to red bone marrow, liver, kidneys, spleen, and all other organs and tissues, respectively. Indium is assumed to be retained indefinitely, however, the committed dose is significantly reduced due to the short physical half-life of ^{111}In.

Iodine-125 (^{125}I)

- Half-life: 60.14 days
- Biological Half-life: 120 days (thyroid); 12 days (whole body)
- Radiation: γ – 0.035 MeV
  E – 0.177 MeV
  X-ray – 0.027 to 0.031 MeV
- Exposure Rate: 1.4 R/hr at 1 cm from a 1 mCi point source (unshielded)
- Occupational Limits: ALI for oral ingestion: 40 mCi (1.5 GBq)
  ALI for inhalation: 60 mCi (2.2 GBq)
- Biological Monitoring: Thyroid scans
- Shielding: 0.02 mm (0.001 in) lead (first half-value layer)
- Detection: Thin window pancake or thin end-window GM detectors; scintillation detectors; liquid scintillation counters; gamma scintillation counters
- Special Considerations: Gamma and x-ray emissions from ^{125}I can present a penetrating external radiation exposure hazard. Individual iodine metabolism can vary considerably. It can be assumed that 30% o iodine uptake is translocated to the thyroid and 70% is directly excreted in urine. Iodine in the thyroid is retained with a biological half-life of 120 days in the form of organic iodine. Organic iodine is assumed to be uniformly distributed in all organs and tissues of the body except the thyroid, and is retained with a biological half-life of 12 days. Retention in the thyroid is reduced by the short physical half-life of ^{125}I.

  Freezing or acidification of solutions containing iodide ions can lead to formation of volatile elemental iodine. Opening a vial of high radioactive concentration of ^{125}I can produce active aerosols. Some iodine compounds can penetrate latex gloves; two pairs or polyethylene alternatives are recommended. NaI is absorbed through the skin extremely rapidly. In the event of a suspected intake, the thyroid may be blocked by the administration of potassium iodate or potassium iodide under appropriate supervision.

  Spills of ^{125}I should be stabilized with alkaline sodium thiosulfate solution before commencing decontamination. Open stock bottles or solutions containing free ^{125}I should not be stored in freezers, refrigerators, or cold rooms. Vials should be opened and used in well-ventilated enclosures.

Iodine-131 (^{131}I)

- Half-life: 8.04 days
- Biological Half-life: 120 days (thyroid); 12 days (whole body)
- Radiation: β^- – 0.248 to 0.606 MeV
  γ – 0.080 to 0.723 MeV
  X-ray – 0.030 MeV
  E – 0.971 MeV
- Maximum Range in Air: Betas – 165 cm (65 in)
- Exposure Rate: 2.16 R/hr at 1 cm from a 1 mCi point source (unshielded)
- Occupational Limits: ALI for oral ingestion: 30 µCi (1.1 MBq)
  ALI for inhalation: 50 µCi (1.8 MBq)
- Biological Monitoring: Thyroid scans
- Shielding: 2.3 mm (0.091 in) lead (first half-value layer)
- Detection: Thin window pancake or thin end-window GM detectors; scintillation detectors; liquid scintillation counters; gamma scintillation counters
- Special Considerations: Beta emission from ^{131}I can present an external exposure hazard to skin and eyes. Gamma emissions from ^{131}I can present a penetrating external radiation exposure hazard. Individual iodine metabolism can vary considerably. It can be assumed that 30% of iodine uptake is translocated to the thyroid and 70% is directly excreted in urine. Iodine in the thyroid is retained with a biological half-life of 120 days in the form of organic iodine. Organic iodine is assumed to be uniformly distributed in all organs and tissues of the body except the thyroid, and is retained with a biological half-life of 12 days. Retention in the thyroid is reduced by the short physical half-life of ^{131}I.

  Freezing or acidification of solutions containing iodide ions can lead to formation of volatile elemental iodine. Opening a vial of high radioactive concentration of ^{131}I can produce active aerosols. Some iodine compounds can penetrate latex gloves; two pairs or polyethylene alternatives are recommended. NaI is absorbed through the skin extremely rapidly. In the event of a suspected intake, the thyroid may be blocked by the administration of potassium iodate or potassium iodide under appropriate supervision.

  Spills of ^{131}I should be stabilized with alkaline sodium thiosulfate solution before commencing decontamination. Open stock bottles or solutions containing free ^{131}I should not be stored in freezers, refrigerators, or cold rooms. Vials should be opened and used in well-ventilated enclosures.

Phosphorous-32 (^{32}P)

- Half-life: 14.29 days
- Biological Half-life: 0.5 to 19 days
- Radiation: β^- – 1.71 MeV
  No gamma (γ)
  E – 1.71 MeV
- Secondary Radiation: Bremsstrahlung (x-ray) significant at 100 mCi levels
- Maximum Range in Air: 6 m (20 ft)
- Occupational Limits: ALI for oral ingestion: 600 µCi (22 MBq)
  ALI for inhalation: 400 µCi (15 MBq)
- Biological Monitoring: Urine samples
- Shielding: 1 cm Plexiglas
- Detection: Thin window pancake (eff. appx. 0.30 cpm/dpm @ 0.25 in) or thin end-window GM detectors; liquid scintillation counters (eff. appx. 0.10 to 0.90 cpm/dpm)
- Special Considerations: High-energy beta emissions from ^{32}P can present a substantial skin and eye dose hazard. Multiple 100 millicurie (3.7 GBq) quantities of ^{32}P can produce significant secondary radiation (bremsstrahlung x-ray), presenting a more penetrating external exposure hazard. Lead shielding placed outside of the plastic shielding can be used to reduce the dose from bremsstrahlung. Uptakes of phosphorous are assumed to be retained with a biological half-life of 0.5 days. Of this phosphorous, 15% is rapidly excreted; 15% is retained in intracellular fluids with a biological half-life of 2 days; 40% is retained in soft tissue with a biological half-life of 19 days; and 30% retained permanently in mineral bone where ^{32}P is reduced by radioactive decay. Approximately 60% of ingested is eliminated the first day. Some radiolabeled compounds are readily absorbed through the skin.

Phosphorous-33 (^{33}P)

- Half-life: 25.4 days
- Biological Half-life: 0.5 to 19 days
- Radiation: β^- – 0.249 MeV
  No gamma (γ)
  E – 0.249 MeV
- Maximum Range in Air: 46 cm (18 in)
- Occupational Limits: ALI for oral ingestion: 6 mCi (220 MBq)
  ALI for inhalation: 3 mCi (110 MBq)
- Biological Monitoring: Urine samples
- Shielding: 1 cm Plexiglas
- Detection: Thin window pancake (eff. appx. 0.09 cpm/dpm @ 0.25 in) or thin end-window GM detectors; liquid scintillation counters (eff. appx. 0.10 to 0.80 cpm/dpm)
- Special Considerations: Millicurie (37 MBQ) quantities of ^{33}P do not present a significant external exposure hazard because the low-energy betas emitted barely penetrate gloves and outer dead skin layers. Uptakes of phosphorous are assumed to be retained with a biological half-life of 0.5 days. Of this phosphorous, 15% is rapidly excreted; 15% is retained in intracellular fluids with a biological half-life of 2 days; 40% is retained in soft tissue with a biological half-life of 19 days; and 30% retained permanently in mineral bone where ^{33}P is reduced by radioactive decay. Approximately 60% of ingested is eliminated the first day. Some radiolabeled compounds are readily absorbed through the skin.

Rubidium-86 (^{86}Rb)

- Half-life: 18.66 days
- Biological Half-life: 44 days
- Radiation: β^- – 0.698 to 1.774 MeV
  γ – 1.077 MeV
  E – 1.774 MeV
- Secondary Radiation: Bremsstrahlung (x-ray)
- Maximum Range in Air: 6.4 m (21 ft)
- Occupational Limits: ALI for oral ingestion: 500 µCi (18 MBq)
  ALI for inhalation: 800 µCi (30 MBq)
- Biological Monitoring: Urine samples
- Shielding: 9.0 mm (0.3 in) lead (first half-value layer)
- Detection: Thin window pancake or thin end-window GM detectors; scintillation detectors; liquid scintillation counters
- Special Considerations: High-energy beta emissions from ^{86}Rb can present a substantial skin and eye exposure hazard. The high-energy gamma emissions and secondary radiation presents a penetrating external hazard. 25% of uptake of ^{86}Rb is assumed to be transferred to the skeleton and 75% uniformly distributed to all other organs and tissues of the body. ^{86}Rb is retained in the body with a biological half-life of 44 days. Finger dosimeters should be worn if handling mCi quantities of ^{86}Rb.

Sodium-22 (^{22}Na)

- Half-life: 2.602 years
- Biological Half-life: 10 days
- Radiation: β^+ – 0.546 MeV
  γ – 1.275 MeV
  E – 2.842 MeV
- Maximum Range in Air: 140 cm (56 in)
- Occupational Limits: ALI for oral ingestion: 400 µCi (15 MBq)
  ALI for inhalation: 600 µCi (22 MBq)
- Biological Monitoring: Urine samples
- Shielding: 6.5 mm (0.26 in) lead (first half-value layer)
- Detection: Thin window pancake or thin end-window GM detectors; scintillation detectors; liquid scintillation counters
- Special Considerations: ^{22}Na positron and gamma emissions present both penetrating and shallow external exposure hazards. Biological half-life varies considerably between individuals and is strongly influenced by level of stable sodium in diet. It may be assumed that 30% of an uptake of ^{22}Na is deposited in the skeleton and mostly retained with a biological half-life of 10 days; 1% of the deposited fraction being retained with a biological half-life of 500 days. All other ^{22}Na in the body can be assumed to be retained with a biological half-life of 10 days.

Sulfur-35 (^{35}S)

- Half-life: 87.4 days
- Biological Half-life: 20 days
- Radiation: β^- – 0.167 MeV
  No gamma (γ)
  E – 0.167 MeV
- Secondary Radiation: Bremsstrahlung (x-ray)
- Maximum Range in Air: 24 cm (9.6 in)
- Occupational Limits: ALI for oral ingestion: 600 µCi (22 MBq)
  ALI for inhalation: 2 mCi (75 MBq)
- Biological Monitoring: Urine samples
- Shielding: 1 cm Plexiglas
- Detection: Thin window pancake (eff. appx. 0.05 cpm/dpm @ 0.25 in) or thin end-window GM detectors; liquid scintillation counters (eff. appx. 0.10 to 0.75 cpm/dpm)
- Special Considerations: Vials should be opened and used in ventilated enclosures. Avoid generation of sulfur dioxide or hydrogen sulfide, which could be inhaled. Radiolysis of ^{35}S-labelled amino acids may lead to the production of volatiles that could contaminate internal surfaces and reaction vessels. Millicurie (37 MBQ) quantities of ^{35}S do not present a significant external exposure hazard since the low-energy emissions barely penetrate the outer layer of dead skin. Metabolism and retention of sulfur compounds in the body vary considerably for different chemical forms. Sulfur uptakes are assumed to be uniformly distributed throughout all organs and tissues in the body. Some radiolabeled compounds are readily absorbed through the skin. Exposure limit for organic compounds may be lower.

Technetium-99 (^{99}Tc)

- Half-life: $2.13E^5$ years
- Biological Half-life: Up to 22 days
- Radiation: β^- – 0.294 MeV
  No gamma (γ)
  E – 0.294 MeV
- Maximum Range in Air: 63 cm (25 in)
- Occupational Limits: ALI for oral ingestion: 400 µCi (15 MBq)
  ALI for inhalation: 500 µCi (18 MBq)
- Biological Monitoring: Urine samples
- Shielding: 1 cm Plexiglas
- Detection: Thin window pancake or thin end-window GM detectors; liquid scintillation counters
- Special Considerations: Millicurie (37 MBq) quantities of ^{99}Tc do not present a significant external exposure hazard because the low-energy betas emitted barely penetrate gloves and the outer layer of dead skin.

Tritium – Hydrogen-3 (^3H)

- Half-life: 12.28 years
- Biological Half-life: 10 days
- Radiation: β^- – 0.019 MeV
  No gamma (γ)
  E – 0.019 MeV
- Maximum Range in Air: 4.7 mm (0.19 in)
- Occupational Limits: ALI for oral ingestion: 8 mCi (300 MBq)
  ALI for inhalation: 8 mCi (300 MBq)
- Biological Monitoring: Urine samples
- Shielding: 1 cm Plexiglas
- Detection: Thin window pancake or thin end-window GM detectors cannot measure the betas of tritium; use liquid scintillation counters (eff. appx. 0.35 cpm/dpm)
- Special Considerations: Some ^3H labeled compounds are readily absorbed through the skin. Millicurie (37 MBq) quantities of tritium do not present a significant external exposure hazard because the low-energy betas emitted cannot penetrate the outer layer of dead skin. Exposure to an atmosphere containing tritiated water results in intake of ^3H by both inhalation and skin absorption. Three to four hours after intake, ingested, inhaled, or absorbed tritiated water is uniformly distributed in all body water. On average, tritiated water is eliminated with a 10-day biological half-life. Elimination rates can be increased by increasing water intake.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix J
Acceptable Experience and Training for Users of Radioactive Material

J.1 General

Use of radioactive material at Texas Tech University Health Sciences Center (TTUHSC) and regional campuses is authorized by Texas Department of Health, Bureau of Radiation Control (TDH-BRC). All activities involving the use of radioactive material must comply with applicable regulations, including the experience and training of radioactive material users. The following guidelines have been established to provide guidance for acceptable training and experience.

J.2 Radioactive Material Sublicensees

The TTUHSC Radiation Safety Committee (RSC) shall determine the adequacy of experience and training of Sublicensees based on the documentation provided at the time of application for Sublicense.

J.3 Authorized Radiation Workers

(a) Experience and training of Radiation Workers shall be reviewed and approved by the RSC prior to commencing work in a radiation use area.

(b) Acceptable documentation of experience and training for individuals seeking authorization as a Radiation Worker include, but are not limited to the following:

(1) Successful completion of the TTUHSC Radiation Safety Short Course (RSSC); or

(2) Documentation of successful completion of an equivalent training course from another academic institution; or

(3) Documentation of successful completion of a minimum 1 credit hour academic course in laboratory radioisotope safety and utilization; or

(4) Documentation of extensive experience in the laboratory use of radioisotopes (i.e. published peer-reviewed papers or publications in which the individual is the first or second author).

J.4 Regional Campus Safety Services Manager

The Regional Campus Safety Services Manager (RCSSM) must have specific radiation safety training through the TTUHSC Radiation Safety Short Course or provide written documentation of equivalent experience and training in the handling and use of radioactive material, use of radiation detection equipment, and basic radioactive material safety. The RCSSM should intern for a period of at least three (3) weeks at the Lubbock campus to become familiar with day-to-day operations and the administration of the TTUHSC Radiation Safety Program.

J.5 TTUHSC Radiation Safety Short Course

The TTUHSC Radiation Safety Short Course will be offered by Radiation Safety Services (RSS) several times a year, according to demand. Personnel working in radioactive material use areas will be required to attend the course or to provide documentation of equivalent training as indicated above. The RSSC course outline is as follows:

(a) Fundamentals of radiation safety:

(1) Characteristics of radiation;

(2) Units of radiation dose (rem);

(3) Activity of radioactivity (curie);

(4) Significance of radiation dose;

(A) Radiation protection standards;

(B) Biological effects of radiation;

(5) Levels of radiation from sources of radiation;

(6) Methods of controlling radiation dose;

(A) Time;

(B) Distance;

(C) Shielding;

(7) Radiation safety practices, including prevention of contamination and methods of decontamination;

(8) Discussion of internal exposure pathways;

(b) Radiation detection instrumentation to be used:

(1) Radiation survey instruments:

(A) Operation;

(B) Calibration;

(C) Limitations;

(2) Survey techniques;

(3) Individual monitoring devices;

(c) Equipment to be used:

(1) Handling equipment and remote handling tools;

(2) Sources of radiation;

(3) Storage, control, disposal, and transport of equipment and sources of radiation;

(4) Operation and control of equipment;

(5) Maintenance of equipment;

(d) Requirements of pertinent federal and state regulations;

(e) The licensee's written operating, safety, and emergency procedures; and

(f) The licensee's record keeping procedures.

J.6 In-Service Radiation Safety Education

RSS will present training on specific subjects when requested to support academic courses or in-service training requirements of personnel.

Texas Tech University Health Sciences Center

Radiation Safety Manual

Appendix K
TTUHSC Radiation Safety Committee Membership

Gwynne H. Little, Ph.D.
Chair, Radiation Safety Committee
Department of Cell Biology & Biochemistry
Lubbock Campus

Elmus G. Beale, Ph.D.
Department of Cell Biology & Biochemistry
Lubbock Campus

Charles A. Bradley, Ph.D.
Department of Pathology
Lubbock Campus

Christopher P. Everitt
Regional Campus Safety Manager
Amarillo Campus
(ex-officio member)

Jayarama B. Gunaje
Department of Pharmaceutical Sciences
Amarillo Campus

Abdul N. Hamood, Ph.D.
Department of Microbiology & Immunology
Lubbock Campus

Lorenz O. Lutherer, M.D., Ph.D.
Department of Physiology
Lubbock Campus

Victor R. Means, III
Interim Director of Safety Services
Radiation Safety Officer
Laser Safety Officer
Lubbock and Regional Campuses
(ex-officio member)

Barbara C. Pence, Ph.D.
Associate Vice President for Research
Associate Dean for Research and the Graduate School
Department of Pathology
Lubbock Campus

Ted W. Reid, Ph.D.
Department of Ophthalmology
Lubbock Campus

Afzal A. Siddiqui, Ph.D.
Department of Internal Medicine
Amarillo Campus

Thomas E. Tenner, Ph.D.
Department of Pharmacology
Lubbock Campus

Ina L. Urbatsch
Department of Cell Biology and Biochemistry
Lubbock Campus

Texas Tech University Health Sciences Center

Radiation Safety Manual

Glossary

Glossary

Absorbed dose – The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the gray (Gy) and the rad.

Activity – The rate of disintegration, transformation, or decay of radioactive material. The units of activity are the becquerel (Bq) and the curie (Ci).

Adult – An individual 18 or more years of age.

Alpha Particle –A charged particle emitted from the nucleus of an atom containing two protons and two neutrons, having a mass and charge equal in magnitude to a helium nucleus.

As Low As Reasonably Achievable (ALARA) – Making every reasonable effort to maintain exposures to radiation as far below the regulatory dose limits as is practical.

Background radiation – Radiation from cosmic sources; non-technologically enhanced naturally occurring radioactive material; global fallout as it exists in the environment from the testing of nuclear explosive devices or from past nuclear accidents, such as Chernobyl, that contribute to background radiation and are not under the control of the licensee. Background radiation does not include radiation from regulated sources of radiation.

Becquerel (Bq) – The SI unit of activity. One becquerel is equal to 1 nuclear disintegration or transformation per second (dps or tps).

Beta Particle – A charged particle emitted from the nucleus of an atom with a mass and charge equal in magnitude to that of an electron.

Bioassay – The determination of kinds, quantities, or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement, in vivo counting, or by analysis and evaluation of materials excreted or removed from the human body.

Bremsstrahlung – Secondary photon radiation (x-ray) produced by the deceleration of charged particles as they interact near the nucleus of an atom in their passage through matter.

Contamination – Deposition of radioactive material in any place where it is not desired, particularly where its presence may be harmful.

Curie (Ci) – A unit of measurement of radioactivity. One (1) curie (Ci) is that quantity of radioactive material that decays at the rate of 3.7×10^{10} disintegrations per second (dps). Commonly used submultiples of the curie are the millicurie (mCi) and the microcurie (μCi). One mCi = 1×10^{-3} Ci = 3.7×10^{7} dps. One μCi = 1×10^{-6} Ci = 3.7×10^{4} dps. One nanocurie (nCi) = 1×10^{-9} Ci = 3.7×10^{1} dps. One picocurie (pCi) = 1×10^{-12} Ci = 3.7×10^{-2} dps.

Decommission – To remove a facility or site safely from service and reduce residual radioactivity to a level that permits the following:

1. Release of the property for unrestricted use and/or termination of license; or
2. Release of the property under alternate requirements for license termination.

Deep dose equivalent (H_d) – External whole body exposure; the dose equivalent at a tissue depth of one (1) centimeter (cm) [1,000 milligrams per square centimeter (mg/cm2)].

Dose – A generic term that means radiation dose.

Dose equivalent (H_T) – The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the sievert (Sv) and rem.

Dose limits – The permissible upper bounds of radiation doses established in accordance with applicable regulations.

Electron – A stable elementary (subatomic) particle having a unit negative charge and a rest mass of approximately 1/1869 amu.

Embryo/fetus – The developing human organism from conception until the time of birth.

Exposure – The quotient of dQ by dm where "dQ" is the absolute value of the total charge of the ions of one sign produced in air when all the electrons (negatrons and positrons) liberated by photons in a volume element of air having mass "dm" are completely stopped in air. The SI unit of exposure is the coulomb per kilogram (C/kg). The roentgen is the traditional unit of exposure.

External dose – That portion of the dose equivalent received from any source of radiation outside the body.

External radiation – Radiation from a source outside the body.

Extremity – Hand, elbow, arm below the elbow, foot, knee, and leg below the knee. The arm above the elbow and the leg above the knee are considered part of the whole body.

Gamma ray (photon) – A form of electromagnetic radiation, of short wavelength, which has its origin from within the nucleus of an excited/unstable atom.

Geiger-Mueller (GM) Counter – A highly sensitive, gas filled, radiation-measuring device which operates at voltages sufficiently high to produce avalanche (secondary) ionizations.

Genetic effect of radiation – Changes produced in the genetic material of a cell, caused by the absorption of ionizing radiation. These changes or mutations, if occurring in gamete cells, can be passed on to offspring. On the basis of current knowledge, these effects are additive in nature, implying that there is no cellular recovery from the damage.

Gray (Gy) – The SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (J/kg) or 100 rad.

Half-life, biological – The time required for the body to eliminate one half of an administered dosage of any substance, through regular processes of elimination.

Half-life, effective – Time required for a radioactive element, which has been assimilated into a body, to be diminished to 50% of its original activity, as a result of the combined action of radioactive decay and biological elimination.

Half-life, radioactive – The time required for a radioactive substance to be diminished to 50% of its original activity through the radioactive decay process. Each radioactive element has its own unique radioactive half-life.

High radiation area – An area, accessible to individuals, in which radiation levels from sources of radiation external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem [1 millisievert (mSv)] in one hour at 30 cm from any source of radiation or from any surface that the radiation penetrates.

Human use – The internal or external administration of radiation or radioactive material to human beings for healing arts purposes or research and/or development specifically authorized by the regulatory agency.

Individual monitoring devices – Devices worn by a single individual for the assessment of dose equivalent. Examples of individual monitoring devices include, but are not limited to, film badges, thermoluminescence dosimeters (TLDs), optically stimulated luminescence dosimeters (OSLs), pocket ionization chambers (pocket dosimeters), electronic personal dosimeters, and personal air sampling devices.

Inspection – An official examination and/or observation including, but not limited to, records, tests, surveys, and monitoring to determine compliance with applicable rules, orders, requirements, and conditions of the regulatory agency.

Internal dose – That portion of the dose equivalent received from radioactive material taken into the body.

Internal radiation – Radiation from a source within the body as a result of inhalation, ingestion or deposition.

Ion – Atomic particle, atom, or chemical radical bearing an electrical charge, either positive or negative.

Ionization – The process by which a neutral atom or molecule acquires a positive or negative charge, through the transfer of kinetic energy from a radiation.

Ionizing radiation – Any electromagnetic or particulate radiation capable of removing tightly bound electrons from their orbits, producing charged atoms or ions. Ionizing radiation includes gamma rays, x-rays, alpha particles, beta particles, high-speed electrons, neutrons, and other nuclear particles.

Isotopes – One of two or more atoms having the same atomic number but different mass numbers. Almost identical chemical properties exist between isotopes of a particular element. The term should not be used as a synonym for nuclide.

Lens dose equivalent – The external dose equivalent to the lens of the eye at a tissue depth of 0.3 cm (300 mg/cm 2).

License – A form of permission given by the regulatory agency to an applicant who has met the requirements for licensing set out in the applicable regulations.

Licensed material – Radioactive material received, possessed, used, or transferred under a general or specific license issued by the regulatory agency.

Liquid scintillation counter – Similar to the scintillation detector described below, except that a liquid is used instead of a solid phosphor. A liquid scintillation counter can be used to detect the presence of alpha particles, beta particles, and low-energy gamma rays.

Member of the public – Any individual, except when that individual is receiving an occupational dose.

Minimum Detectable Activity (MDA) – The threshold of detection for a biological response, substance, or device in question.

Minor – An individual less than 18 years of age.

Natural radioactivity – Radioactivity of naturally occurring nuclides whose location and chemical and physical form have not been altered by man.

Non-ionizing radiation - Radiation without enough energy to remove tightly bound electrons from their orbits around atoms. Examples are microwaves, lasers, and visible light.

NRC – The United States Nuclear Regulatory Commission (NRC) or its duly authorized representatives.

Nuclear disintegration – A spontaneous nuclear transformation characterized by the emission of energy and/or mass from the nucleus. When numbers of nuclei of the same element are involved, the process is characterized by a definite half-life for that element.

Nuclide – A type of atom specified by its atomic number, atomic mass, and energy state, such as carbon 14.

Photon – A quantity of electromagnetic energy. Photon is a common term for both x-ray and gamma radiation.

Proton – Elementary nuclear particle with a unit positive charge and a rest mass equal to 1.00728 amu.

Quality factor – The linear energy transfer dependent factor by which absorbed dose is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the effectiveness of the absorbed dose.

Rad – The traditional unit of absorbed dose. One (1) rad is equal to an absorbed dose of 100 ergs per gram (erg/g) or 0.01 J/kg (0.01 gray).

Radiation – The emission and propagation of energy through space or through a material or medium in the form of waves, such as electromagnetic waves, or sub-atomic particles, such as electrons, protons, or neutrons. One or more of the following: gamma rays, x-rays, alpha particles, beta particles, neutrons, and other atomic or nuclear particles or rays.

Radiation area – Any area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in one hour at 30 cm from the source of radiation or from any surface that the radiation penetrates.

Radiation Safety Committee (RSC) – A committee appointed by the TTUHSC President or designee charged with oversight of the TTUHSC Radiation Safety Program.

Radiation Safety Officer (RSO) – An individual who has a knowledge of and the authority and responsibility to apply appropriate radiation protection rules, standards, and practices, who must be specifically authorized on a radioactive material license, and who is the primary contact with the regulatory agency.

Radiation Worker – An individual engaged in work under a license or certificate of registration issued by the regulatory agency and controlled by a licensee or registrant, but does not include the licensee or registrant.

Radioactive decay – The disintegration of the nucleus of an unstable atom accompanied by the spontaneous emission of neutrons and/or charged particles and/or photons.

Radioactive material – Any material (solid, liquid, or gas) that emits radiation spontaneously.

Radioactive Material License – A form of permission given by the regulatory agency to an applicant who has met the requirements for licensing set out in the applicable regulations.

Radioactive Material Sublicense - A form of permission given by the Radiation safety Committee to an applicant who has met the requirements for licensing set out in the applicable regulations and the TTUHSC Radiation Safety Manual.

Radioactivity – The disintegration of unstable atomic nuclei with the emission of radiation.

Radiological survey – Evaluation of the potential radiation hazards incident to the production, use or storage of radioactive materials in a location. Such evaluation customarily includes a physical area survey, using an appropriate survey instrument, and a removable contamination survey, using wipe survey techniques.

Rem – The traditional unit of any of the quantities expressed as dose equivalent. The dose equivalent in rem is equal to the absorbed dose in rad multiplied by the quality factor [1 rem = 0.01 sievert (Sv)].

Roentgen (R) – The traditional unit of exposure. One (1) roentgen (R) equals 2.58 X 10^{-4} C/kg of air. (See definition for exposure.)

Scintillation detector – A highly sensitive instrument used primarily for the detection of x-ray and gamma radiation. It is a combination of a phosphor [typically a sodium iodide (NaI) crystal], optically coupled with a photomultiplier tube and associated electronic circuitry for converting and counting light emissions produced in the phosphor.

Sealed source – 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.

SI unit – A measurement unit of the International System of Units

Sievert (Sv) – The SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sievert is equal to the absorbed dose in gray multiplied by the quality factor (1 Sv = 100 rem).

Sublicense – A form of permission given by the Radiation Safety Committee to an applicant who has met the requirements for sublicensing set out in the Radiation Safety Manual.

Sublicensee – A qualified individual granted a Radioactive Material Sublicense by the Radiation Safety Committee.

Unrestricted area (uncontrolled area) **–** An area, or access to an area that is neither limited nor controlled by the licensee.

Very high radiation area – An area, accessible to individuals, in which radiation levels from sources of radiation external to the body could result in an individual receiving an absorbed dose in excess of 500 rads (5 grays) in one hour at 1 meter (m) from a source of radiation or from any surface that the radiation penetrates.

Whole body – For purposes of external exposure, head, trunk (including male gonads) arms above the elbow, or legs above the knee.

Worker – An individual engaged in work under a license or certificate of registration issued by the regulatory agency and controlled by a licensee or registrant, but does not include the licensee or registrant.

X-rays – Electromagnetic waves or photons not emitted from the nucleus of an atom, but normally emitted during energy changes in electrons. These energy changes in electrons occur in either the electron orbital shells that surround an atom, or during the process of electrons slowing down or changing direction.