RADIATION SAFETY PLAN

THE UNIVERSITY OF TEXAS AT SAN ANTONIO

OFFICE OF RESEARCH INTEGRITY

LABORATORY SAFETY DIVISION

REVIEW PAGE

This Radiation Safety Plan for Radioactive Material Use has been reviewed for regulatory compliance and best management practices by the undersigned individuals and is hereby adopted for use and compliance by all employees at The University of Texas at San Antonio pending approval of the Texas Department of State Health Services (TXDSHS).

NAME	TITLE	DATE
Amanda Haley	Interim Laboratory Safety Manager	10-31-2018
Dianna Olukotun	Radiation Safety Officer	10-31-2018
Michelle Stevenson	Associate Vice President of Research Integrity	10-31-2018
Ruyan Guo	Chair, Radiation and Laser Safety Committee	10-31-2018

COMMITTEE

COMMITTEE	REVIEW DATE	APPROVAL DATE
Radiation and Laser Safety Committee	10-18-2018	10-31-2018

This manual took effect as of July 2011 with the approval of Texas Department of State Health Services of UTSA's license renewal dated June 24, 2010.

This plan was reviewed/revised on 8/6/18 and replaces the 3/7/14 version. Changes to this plan are minor and have been highlighted in "gray" and are summarized below by section:

Emergency Telephone Numbers. Updated Radiation & Laser Safety Coordinator's name.

V.A.4. Updated Leak Tests of Sealed Sources

VI.B.2.b. Placed material in parentheses in two sentences.

VI.G.3.b. Removed "or underwater".

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EMERGENCY TELEPHONE NUMBERS

	Extension	After 5pm
RADIATION SAFETY OFFICER (RSO)		
Dianna Olukotun Office of Research Integrity Room: GSR 2.104T	5807	4242
RADIATION & LASER SAFETY COORDINATOR		
Dianna Olukotun Office of Research Integrity Room: GSR 2.104V	5807	4242
UNIVERSITY SAFETY OFFICER		
Environmental Health, Safety & Risk Management Room: SSB A 1.102	5250	4242
UNIVERSITY POLICE		
Room: PP 1.416	4242	4242
ALL EMERGENCIES (UTSA Police Dispatcher)		
Calling from a campus phone	911	911
Calling from a cell phone or outside line	458-4911	458-4911
UTILITY OUTAGES (Facilities Services)	5277	5277

See Appendix B for **UTSA RADIATION EMERGENCY PROCEDURES** sign. A copy of this sign provided by the RSO **must** be posted in a conspicuous location in each laboratory utilizing radioactive materials.

In the event of a fire, explosion or other serious incident with radioactive or hazardous materials, call the UTSA Police Department as soon as possible (911 on a university phone) and **BE PREPARED TO PROVIDE THE DISPATCHER WITH THE FOLLOWING INFORMATION-BUT DO NOT DELAY AN EMERGENCY CALL TO ACCUMULATE THIS INFORMATION:**

Location of the fire/incident:	(BUILDING & ROOM/LAB NUMBER)
Hazardous materials involved	(RADIOACTIVE MATERIAL/NAME/TYPE)
If medical assistance is needed:	(TYPE OF INJURY & NUMBER INJURED)

I. OVERVIEW

The University of Texas at San Antonio (UTSA) Radiation Safety Plan contains the current official radiation safety procedures for UTSA and serves as the guidance document for the institution's radiation safety and protection program. The purpose of this plan is to provide information and establish general procedures on the proper use and handling of radioactive materials. Radiation Safety Personnel (RSP) should be consulted for explanations or additional information.

All personnel who work, or are planning to work, with radioactive materials are responsible for knowing and adhering to this plan. It is the users' responsibility to be aware of the hazards associated with the use of radiation and to obey all UTSA policies and State and Federal Regulations concerning radiation doses received by occupationally exposed personnel and the general public. This plan (based on regulations published by the TX DSHS) is a description of practices and regulations regarding the safe handling and use of radioactive materials. All requirements and regulations stated in the plan must be obeyed. Failure to do so is a citable violation and could result in loss of the privilege to use radioactive material for an individual or laboratory. Repeated violations or deviations from the approved procedures may jeopardize any use of ionizing radiation at UTSA.

II. SCOPE

The UTSA Radiation Safety Plan applies to persons who receive, possess, use, or transfer radioactive materials, unless otherwise exempted. The plan applies to all facilities owned, operated or leased by UTSA, to all personnel who work on these facilities, and all equipment owned or leased by UTSA or used within the premises of UTSA. No person may use, manufacture, produce, transport, transfer, receive, acquire, own, possess, process, or dispose of radioactive materials unless that person has a license or exemption from the TX DSHS and approval of the RSO and R&LSC. All licensing will be administered institutionally by the RSO.

The dose limits in this section do not apply to doses from background radiation. The limits do not include exposures of patients to radiation for the purpose of medical diagnosis or therapy or to voluntary participation in medical research programs. No radiation may be deliberately applied to human beings except by or under the supervision of an individual authorized by and licensed in accordance with Texas' statutes to engage in the healing arts. Medical research programs must also be approved by the Institutional Review Board (IRB) and the TX DSHS.

III. PERIODIC REVIEW

The contents of this plan will be reviewed when relevant sections of the Texas Administrative Code (TAC) on the use of radioactive material are changed or when internal policies mandate a review, but at least every three years.

IV. RESPONSIBILITIES

A. RESPONSIBILITIES OF THE RADIATION SAFETY OFFICER / RADIATION SAFETY PERSONNEL INCLUDE:

a. Reviewing all proposals for use of radioactive material and approving or disapproving them in conjunction with the Radiation & Laser Safety Committee (R&LSC).
b. Inspecting facilities and equipment where or with which radioactive materials are used to ensure radiation safety requirements are met.
c. Performing routine and special surveys in regards to contamination control and dose measurements.
d. Establishing special conditions and requirements as may be necessary for safe and proper use of all radioactive materials.
e. Acting as a consultant in the design of all new facilities using radioactive materials, or constructed for the purpose of providing protection against radiation exposure.
f. Preparing and disseminating information on radiation safety to the UTSA community.
g. Supervising the UTSA training course on radiation safety.
h. Receiving, storing, processing and delivering radioactive material orders, and maintaining records on all such transactions.
i. Supervising the proper disposal of radioactive waste including effluent releases.
j. Providing personnel monitoring services, including the review and recordkeeping of commercially processed dosimeter reports.
k. Performing or directing all bioassays and environmental surveys as needed.
l. Preparing license applications, amendment applications, and required reports as well as acting as the contact point for all correspondence with State and Federal radiation health regulatory agencies.
m. Investigating unusual radiation exposures, incidents, and accidents and reporting corrective action to the principal investigator, supervisory personnel, and R&LSC.
n. Performing an annual Radiation Protection Program (RPP) audit and reporting the results to the R&LSC.
o. Maintaining calibrations and quality control programs of radiation safety equipment used by RSP.
p. Verifying that proper postings and signage is being utilized in areas working with radioactive materials.

B. RESPONSIBILITIES OF THE PRINCIPAL INVESTIGATORS (PIs) INCLUDE:

a. Completing the required UTSA Radiation Safety Training course or equivalent approved by the RSO.
b. Establishing and maintaining specific, written laboratory safety procedures and providing these procedures to the RSO.
c. Ensuring all laboratory personnel complete the Radiation Safety Training course, receive specific training for the safe use of radioactive materials used in the laboratory and the proper use of radiation detection instruments.
d. Ensuring that laboratory personnel have thorough knowledge of this plan and the regulations pertinent to radioactive material use.
e. Ensuring that all radioactive materials under their control have been properly approved and that all potential hazards are brought to the attention of RSP.

f. Ensuring all appropriate radiation surveys are conducted and all necessary records with regards to radioactive materials are maintained.
g. Ensuring all experiments or procedures using 125I, radioactive gases, labeled DNA precursors and/or labeled materials that have radioactive levels of 100 mCi or more are approved in advance by the R&LSC and are performed in a fume hood specifically identified for this purpose.
h. Notifying RSP when new personnel are added or when personnel under their supervision will be leaving the laboratory.
i. Labeling areas and radioactive materials properly.
j. Preventing unauthorized access to radioactive materials by properly securing them within the laboratory at all times.
k. Notifying RSP prior to vacating premises to allow a thorough closeout survey of surfaces and equipment.
l. Providing equipment and shielding in order to maintain doses ALARA.

C. RESPONSIBILITIES OF LABORATORY PERSONNEL INCLUDE:

a. Following procedures of safe practice contained in this plan and those specific to the laboratory as provided by the PI.
b. Keeping exposures to radiation as low as possible.
c. Wearing appropriate dosimetry, clothing and personal protective equipment when working in the laboratory with radioactive materials.
d. Reporting immediately to the PI and RSP any suspected exposure in excess of permissible limits or any laboratory activities which could lead to unnecessary exposure.
e. Reporting any contamination to a dosimeter to prevent any cross-contamination of other dosimeters.
f. Immediately reporting a lost or stolen dosimeter to RSP.
g. Monitoring for and promptly removing radioactive contamination after first having consulted with RSP, if necessary.
h. Reporting accidents or injuries involving radioactive materials, promptly to RSP.
i. Storing and labeling of radioactive materials properly.
j. Packaging and labeling waste for disposal and maintaining records of such disposals.
k. Performing appropriate surveys and maintaining records of results.
l. Contacting RSP at least ONE WEEK before leaving the laboratory or UTSA.
m. Assuring that acquisitions and transfers of radioactive materials are made in accordance with the provisions of this plan.
n. Complying with requests from RSP for bioassay. See section V.A.5. Bioassays, for specific information.
o. Preventing unauthorized access and possible removal of radioactive materials.

D. RESPONSIBILITIES AND AUTHORITIES OF THE RADIATION AND LASER SAFETY COMMITTEE (R&LSC) INCLUDE:

a. Formulating policies and procedures and providing the oversight necessary for the control of radioactive materials, radiation-producing machines, and ionizing radiation hazards.
b. Meeting as often as required by regulations or the number of applications submitted, but at least three times per year.

c. Reviewing all proposals for use of radioactive material and approving or disapproving them in conjunction with the RSO.
d. Reviewing complaints of violations of procedures and/or regulations pertaining to radioactive materials at UTSA.
e. Revoking permission to utilize radioactive materials for serious violations of procedures or regulations and reporting to TX DSHS as required.

V. GENERAL INFORMATION

A. RADIATION SAFETY PROCEDURES

1. Radioactive Material Safety Rules

The Safety Rules that are contained in this Plan are designed to protect four types of individuals:

a. Laboratory personnel - The people who work on a day to day basis in a laboratory that utilizes radioactive materials, whether or not they actually handle the sources directly.
b. Faculty/staff personnel - The people who are responsible for supervision of laboratory personnel who handle radioactive materials and the University employees that must enter the laboratory containing radioactive materials for maintenance and/or repair of facilities or other duties.
c. Students - The people who are being trained in the laboratory setting, whether or not their training/education program directly deals with the handling of radioactive materials.
d. Other persons - The people who are internal or external to UTSA, who, without their knowledge or permission, may be exposed to radiation.

2. Survey Procedures

a. Handling of radioactive materials in the form of gases, liquids and/or solids in the laboratory necessitates both radiation surveys and contamination surveys to prevent unnecessary radiation exposure. Furthermore, these surveys are required to prevent the spread of radioactive contamination throughout UTSA. Radiation surveys are performed by using a radiation survey meter. Contamination surveys are performed by taking swipe samples from areas where work with radioactive material is being carried out or where contamination is suspected or might occur. See sections VI.D. Radiation Surveys and VI.G. Decontamination for frequency and methods for performing surveys and decontamination.
b. In unrestricted areas radiation levels must be controlled so that a person cannot exceed dosage levels of 100 mR/yr or 2 mR/hr. For restricted areas, radiation levels should be as low as achievable with adequate shielding as assessed by RSP.
c. Wipe samples indicating 1000 disintegrations per minute (dpm)/100 cm^2 must be cleaned until the contamination is removed. Since this level is sometimes difficult to establish, whenever a wipe sample shows a detectable amount of activity above background, the area should be cleaned.

3. Personnel Monitoring – Dosimetry

a. Use of a dosimetry badge requires consideration of the properties of the radiation, the level of potential exposure, and the complexity of the application.
b. Commercial badge services make it technically feasible to obtain reliable readings at exposure levels down to 1 millirem. Although exposure at this low level is not very significant, monitoring may be provided to help the user practice exposure ALARA (as low as reasonably achievable) in routine operations or document exposure during an accident. Also to be noted, alpha, low-energy beta radiations (e.g. 3H and 14C), and neutrons of certain energies are not detected by film, Luxel, or TLD badges.

c. Any person likely to receive 10% or more of the applicable annual allowable dose limit is required to utilize a dosimetry badge or other appropriate monitoring device. RSP will determine if a person is likely to receive this dose level.

d. In order to obtain meaningful information from the use of a badge, the following guidelines must be observed:

   i. Adopting the Appropriate Badge:

      1. RSP will determine the appropriate type of badge and the change frequency for the conditions to be encountered.
      2. Types of dosimeters used to monitor whole body exposure include beta-gamma x-ray, and neutron beta-gamma x-ray dosimeters. Thermoluminescent (TLD) dosimeters are used for monitoring exposure to hands or wrists. Luxel or TLD dosimeters are required for persons who routinely handle millicurie quantities of gamma emitters or highly energetic beta emitters such as 32P. Both types of dosimeters are processed quarterly.
      3. **NOTE: A badge or dosimeter should be processed immediately whenever an unusual or excessive exposure is suspected. Call the RSP if such circumstances arise.**

   ii. Proper Use of the Badge:

      1. Only the person who is assigned a badge should wear it. Do not loan a badge or use it for monitoring an area.
      2. It is essential to monitor the portion of the body receiving the highest exposure.
      3. The dosimetry badge is used to measure occupational exposure to radiation. It must be worn whenever working with radioactive materials or when in an area where exposure might occur at UTSA. The badge must not be worn away from UTSA, especially when receiving medical radiation exposure, such as diagnostic x-rays or nuclear medical treatments.

   iii. Declared Pregnant Worker

      1. Pregnant workers must declare their pregnancy in writing in order for the fetal dose limits mandated by the state and federal governments to take effect. This declaration is voluntary and the worker is not required to do so. Standard dose limits apply if a written declaration has not been made to the RSO.
      2. Declared pregnant workers will be provided a dosimetry badge to be worn on the abdomen. This is used to monitor fetal dose.
      3. The fetal dose limits are 500 mrem per term and 50 mrem per month.
      4. A declaration can be rescinded at any time in writing by the worker.

4. Leak Tests of Sealed Sources

All nonexempt, licensed, sealed sources will be tested every thirty six months (or more frequently if requested by the user) by a firm licensed by the Texas Department of State Health Services to measure for leakage. All generally licensed sealed sources will be tested per the manufacturer's recommendations. Sealed sources must be shown to exhibit removable levels of less than 0.005 µCi. Samples will be taken by RSP and mailed to the firm for analysis.

5. Bioassays

a. RSP will perform all bioassays in accordance with the conditions of UTSA's license, or when ingestion or inhalation of radioactive materials is suspected. Any significant, positive results will initiate an investigation of the working conditions and procedures used in working with radioactive materials. Follow-up bioassays will be performed as required by the situation. The reports of the bioassay become part of the individual's exposure history and are kept on file.
b. Persons handling 100 mCi of tritiated (^3H) material will submit a urine sample per RSP instructions within twenty-four hours to determine tritium levels. Persons handling unbound radioactive iodine are required to contact RSP regarding the thyroid bioassay program. A baseline level must be obtained prior to initiation of work with unbound iodine. Periodic checks will be performed to determine any uptake and compared to established action levels. Action levels in both cases will result in investigations and follow-up actions and reporting.

6. Exposure Limits for Radiation Workers

a. The maximum permissible dose limits as per 25 TAC §289.202 are specified in the following list:

Annual Limits for Adults

  i. The total effective dose equivalent being equal to: 5 rem or;
  ii. The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to: 50 rem
  iii. A shallow dose equivalent to the skin or to any extremity of: 50 rem
  iv. An eye dose equivalent of: 15 rem

b. Additional recommended limits for special situations include:
  v. Fetus during entire pregnancy not to exceed: 0.5 rem
  vi. Students under 18 years old are not exceed 10% of the annual adult dose limits.

7. Radiation Safety Training

A formal Radiation Training Course is available for all personnel handling radioactive materials. This course must be completed by all personnel prior to working in a laboratory which uses or stores radioactive material unless an exception for prior training has been granted by the RSO. The course covers:

a. The fundamentals of radiation safety including the characteristics of radiation, units of radiation dose (rem) and activity (curie), significance of radiation dose (radiation protection standards and biological effects of radiation), levels of radiation from sources of radiation, methods of controlling radiation dose (time, distance and shielding), radiation safety practices (prevention of contamination and methods of decontamination), and discussion of internal exposure pathways.
b. Radiation detection instrumentation to be used, including radiation survey instruments and their operation, calibration and limitations. Survey techniques and individual monitoring devices to be used by laboratory workers using radioactive materials.
c. Equipment to be used including handling equipment and remote handling tools, sources of radiation, storage, control, disposal, and transport of equipment and sources of radiation, operation and control of equipment and maintenance of equipment.
d. The requirements of pertinent federal and state regulations.
e. UTSA’s written operating, safety and emergency procedures.

f. UTSA's record keeping procedures.

B. BASIC PRINCIPLES AND GUIDELINES IN RADIATION PROTECTION

1. Biological Effects of Radiation

Interaction with ionizing radiation can result in biological damage. This damage can occur at various levels: atomic, molecular, cellular, organ or whole body. The damage is a result of complex series of chemical events involving charged particles, electrical interactions, ionization or chemical changes.

Damage from radiation interactions can be direct or indirect. Direct interactions with biological molecules can cause damage to the molecule, such as DNA, which can result in changes in the cell and possible cell death. Indirect damage can be the result of reactive free radicals formed by interactions.

The type and amount of damage caused is influenced by the type of radiation, the dose, the dose rate and the radiosensitivity of the cells affected. Cells which are unspecialized, immature cells with a long dividing future and cells that have a high division rate have a greater radiosensitivity.

Biological effects can be somatic or genetic. Somatic effects are those effects seen in the exposed person. Somatic effects can be deterministic or stochastic. Deterministic effects have threshold levels and the severity is proportional to the dose received. Stochastic affects are probabilistic. The probability of occurrence is proportional to the dose received. Early somatic effects occur within hours to weeks after exposure and include: nausea, fatigue, erythema, epilation, blood and intestinal disorders. Late somatic effects occur months or years after exposure and include: cataractogenesis, carcinogenesis, and embryologic (birth) defects. Genetic effects are those effects seen in the offspring of exposed organisms. Genetic effects can be dominant or recessive and result from changes in ova or sperm of parents. Genetic effects have only been seen in flies and rodents in laboratory settings. These effects have not been noted to this point in humans.

The most serious biological effect is Acute Radiation Syndrome (ARS) which is caused by an acute high dose exposure greater than 50 rem to the whole body. There are three types of ARS; bone marrow syndrome, gastrointestinal syndrome, and central nervous system syndrome.

There are four stages of ARS:

a. The first is prodromal stage which includes the classic somatic symptoms within minutes to days of exposure and lasting minutes to several days.
b. The second is latent stage where the person looks and feels healthy for a few hours to weeks.
c. The third is manifest illness stage where illness lasts between hours and months and the specific symptoms depend on the type of ARS.
d. The fourth is recovery or death stage in which the person either recovers or dies.

2. Basic Principles

It is the responsibility of any person involved in radiation procedures to minimize his or her own exposure to ALARA. The following principles, which apply to whatever form of radiation or radioactive material is present, will help personnel reduce their exposure to levels that are ALARA.

a. **Distance**: Radiation exposure is inversely proportional to the square of the distance from the source; thus, maintaining distance from radioactive material offers protection.

b. **Time:** Since accumulated dose is directly proportional to time exposed, the less time one spends around radioactive material, the less radiation exposure one receives.

c. **Shielding:** Shielding offers a form of protection that requires prior planning and anticipation of safety requirements for given work. Protection offered by shielding depends on the following:

   i. Initial radiation dose rate without shield.
   ii. Material used for shielding -- the denser the material, the better it is as a shield.
   iii. Thickness of the shield.
   iv. Type and energy of radiation.

3. Calculation of Exposure and Dose Rates

a. Approximate Exposure Rate from Gamma-Emitting Point Source

   mR/hr at 1 foot _~ 6 CEn

   Where: C = activity in millicuries

   E = gamma ray energy in MeV

   n = percent abundance for that specific energy

b. Exposure Rate from Gamma Point Source

   $mR/hr = 10^3 N \Gamma d^{-2}$

   Where: N = activity of source in millicuries

   Γ = gamma dose rate constant for that nuclide in R/hr-mCi at 1cm (see Appendix C)

   d = distance from source in centimeters

c. Approximate Dose Rate from a Beta Point Source

   $mrads/hr = 3.1 \times 10^5 N d^{-2}$

   Where: N = the activity of the source in millicuries

   d = distance from the source in centimeters

Notes on Approximate Dose Rate from a Beta Point Source

   i. The maximum energy of the beta particles must be 0.5 MeV.
   ii. **d** must be small with respect to the maximum range of the beta particles in air; otherwise, there will be absorption. The dose rate thus derived will be conservatively high from the radiation protection standpoint.

d. Relationship between Exposure Rate and Distance from Source

   $I_2 = I_1 [(d_1)^2/(d_2)^2]$

   Where: I_2 = exposure (dose) rate at distance d_2

   I_1 = exposure (dose) rate at distance d_1

   (The distances must be in the same units)

e. Radioactive Decay

   $A = A_o e^{-kt}$

   From which, $\ln(A) = \ln(A_o)^{-kt}$, In $(A/A_o) = \ln(e^{-kt})$

   Where: A = activity remaining after the time interval t

   A_o = activity at some original time

   e = base of natural logarithm system = 2.7183

   t = the elapsed time

   k = the decay constant for a particular radionuclide

$k = \ln2/t1/2$
$\ln2 = 0.693$
t1/2 = the physical half-life of the radionuclide
NOTE: t1/2 and t must be in the same units.

4. Shielding of Gamma Radiation Sources

$I = BI_o e^{-\mu x}$

Where: B = build up factor (dependent upon composition of shielding, the energy of the gamma radiations and the thickness of shield). See Radiological Health Handbook, 1970 Edition, PHS Publication No. 2016.
I_o = the original exposure rate
e = base of natural logarithm system = 2.7183
x = the shield thickness
μ = the linear absorption coefficient (reciprocal units of the shield thickness)
NOTE: $\mu = (\mu a/\rho)\rho$

Where: $\mu a/\rho$ is the mass absorption coefficient.
See NSRDS-NBS Report No. 29 for values of $\mu a/\rho$
ρ = the density of the shielding or
$\mu = \ln2/x^{1/2}$
where:ln2 = 0.693
$x^{1/2}$ = the amount of shielding that will reduce the radiation intensity by half.

VI. UTSA POLICIES APPLICABLE TO THE USE OF RADIOACTIVE MATERIALS

A. AUTHORIZATION TO USE RADIOACTIVE MATERIALS

a. Approval to use radioactive materials is obtained in the following manner:
    a. A memorandum must be sent to the RSO/R&LSC covering the following items in the order listed:
        i. Name and title of applicant (project supervisor).
        ii. Curriculum Vita
        iii. Building and room. Include a SKETCH (building drawings can be obtained from Facilities) of the room showing facilities to be used.
        iv. Names and titles of technically trained faculty, staff and students participating in the project. List the completion date of the UTSA Radiation Safety Training course or approved equivalent for each person.
        v. If material is to be used in class work, indicate whether persons under 18 years of age may be present and the anticipated exposure rate. Arrange for the class to take the UTSA Radiation Safety Training course.
        vi. The radioisotope(s), chemical form and maximum quantity to be used per experiment, frequency of experiments, maximum quantity to be obtained per order, maximum to be possessed at any time and an estimate of potential exposures to gamma and beta emitters.

vii. Proposed use. Briefly outline the procedures to be followed; describe the procedures to be followed in sufficient detail to permit a radiation safety evaluation to be made by the RSO and R&LSC. **Allow sufficient time for this review**.

viii. List protective equipment (e.g., fume hoods, shielding, etc.) to be used. Include plans for handling and storing radioactive materials, care of animals exposed to radioactive materials, disposal of radioactive wastes, etc. List survey instruments that are available for surveys by laboratory personnel. Each laboratory is required to have suitable monitoring instrumentation for detection of the radiation.

ix. If a fume hood is to be utilized, a detailed protocol is required and must include in addition to the information listed above, the procedure for monitoring the effluent (and/or containment) and an estimated minimum and maximum effluent given off during the experiment.

NOTE: A specially designated fume hood must be utilized for experiments involving ^{125}I, radioactive gases, labeled DNA precursors and/or labeled materials in excess of 100 mCi.

x. If this is a first experiment, give a brief but explicit description of the previous experience and training of the persons listed in number four. Particularly, emphasize experience with and knowledge of radiation.

xi. Enumerate safety considerations that are involved and the measures that will be taken to implement radiation safety. Indicate how possible personnel and facility contamination will be assessed.

b. Approval for a project generally will be for a period of one to three years. At the end of this period, the project supervisor will have to update the application.

Please note that the above information is not only required for internal UTSA review, but also for the licensing division of the TX DSHS Radiation Control Program and is forwarded to them for addition to the license. **No one at UTSA may order radioactive materials unless they have been approved and placed on UTSA's Radiation License.**

B. ACQUISITION OF RADIOACTIVE MATERIALS

1. Purchase of Radioactive Materials

Radioactive materials may be ordered only by persons who have obtained official authorization to use such materials. Official authorization involves listing on the Radiation License for UTSA after approval by TX DSHS and the R&LSC. All purchase requests for radioactive materials must be submitted to RSP for approval. Providing the amount of material requested does not exceed the authorized inventory level for UTSA and the radioisotope is approved on the Radiation License, the purchase request will be approved by RSP. Without this approval the Purchasing and Accounting departments will not process the order. To ensure orders are processed in a timely manner, call RSP or send an email indicating that an order has been submitted for approval.

2. Receipt of Radioactive Materials

a. *Inspection by RSP*. After receipt of radioactive materials by Central Receiving Warehouse (CRW) personnel, RSP will be notified. The packing slip of all packages received will be examined to determine that the correct radioisotope, chemical form, and amount of material has been received. All packages will be examined for signs of damage. All packages will be surveyed for external radiation levels with a hand-held meter equipped with a thin end-window G-M probe or a NaI crystal detector. Radiation levels must not exceed 200 millirems/hr at the surface or 10 millirem at 1 meter [25 TAC §289.202(ee)]. For Yellow II and Yellow III labeled packages, the dose rate expected at 1 meter from the package surface is that indicated by the "transport index" on the label. The dose rate at the surface should not exceed 200 millirems/hr. The dose rate for "White I" labeled packages should not exceed 0.5 millirems/hr at the surface. Since a survey meter will not readily detect low levels of removable contamination from weak beta or gamma emitters, all packages will also be wipe tested at various locations over a total of ~300 cm^2 for removable external contamination. These wipe tests will be analyzed by a liquid scintillation counter. When the package is determined to be acceptable, RSP will deliver the package to the authorized use location. The user will be responsible for inspecting the contents inside the package and verifying the actual contents. For packages that are damaged and contaminated or exceed the limits on external radiation or removable contamination, the package will be held for return and the final delivery carrier and the TS DSHS will be immediately notified by telephone and in writing (e.g., facsimile).

b. *Opening and inspection of package by user*. Put on gloves to prevent hand contamination. Inspect the package for signs of visible damage at the point of opening and notify RSP if damage is observed at any time during opening and no further handling will occur. If external radiation levels are greater than expected, stop and notify the RSP. Remove and read the (Material) Safety Data Sheet and the copy of the packing slip. Open the inner package and verify that the contents agree with the packing slip and the material ordered. Check the integrity of the final inner container. Look for broken seals or vials, loss of liquid, condensation, or discoloration of the packing material. If anything appears damaged or out of place, stop and notify RSP. Perform a wipe test on the final inner container. Until the results of the wipe test are obtained, assume that the materials received may be contaminated and take precautions to prevent the potential spread of contamination. Monitor the packing material and the empty packages with a survey meter before discarding. If contamination is discovered for any packing material, it must be treated as radioactive waste. If not contaminated, remove or destroy all radiation labels or indicators prior to discarding in the trash. DO NOT DISCARD NON-RADIOACTIVE MATERIALS IN RADIOACTIVE WASTE. Record the amount and type of radioisotope received and begin a log of use for the material in that package (put the (Material) Safety Data Sheet in the Radiation Log notebook along with the wipe test results).

3. Acquisition of "No Charge" Radioactive Materials

The RSO must be notified and give approval prior to the acquisition of "no-charge" (free) radioactive materials. Only those persons with official authorization may obtain such materials if there is an immediate need and the material will not become a disposal problem.

4. General License Materials

For research purposes small quantities of certain isotopes can be purchased without a specific license. These General License materials are subject to similar requirements for record keeping, contamination control, and waste disposal accounting. No General License Material shall be acquired or disposed of without the RSO's approval.

C. ACCOUNTABILITY FOR RADIOACTIVE MATERIALS

1. Locations of Use

Radioactive materials may only be used in those facilities that have been approved and placed on UTSA's Radiation License. Investigators wishing to expand their areas or move into new areas must submit an application that includes a description of the area (fixtures, storage, etc) and any other required features along with a floor plan with usage and storage areas marked. Approval is specific to a particular user for a particular radioactive material and purpose.

2. Transfer of Radioactive Materials

There are a variety of circumstances that may arise which make it desirable to transfer radioactive materials from one laboratory to another. Since the RSP and R&LSC <u>must</u> be informed of the status of radiation use in all campus areas at all times, the following general procedures must be observed.

a. <u>On Campus Transfer</u>. The transferor must inform RSP to assure that the recipient has been authorized to use the specific radioactive material being transferred. Submit the following information to RSP and R&LSC for advance approval. Transfer, especially between floors or buildings, must be approved in advance by RSP.
    i. Radioactive material to be transferred
    ii. Chemical and physical form
    iii. Activity (in microcuries)
    iv. Name and department of transferor
    v. Name and department of recipient
    vi. Current location and transfer location

c. <u>Off Campus Transfer</u>. Consult RSP for the procedure to be followed. It is necessary to arrange in advance receipt of the material at its destination and proper transportation requirements must be met depending upon the radioactive material to be shipped. RSP will coordinate with CRW to prepare materials for commercial transportation. Private transportation is not allowed and might cause serious liability. Proper shipping training with documentation is required for anyone shipping radioactive materials.

3. Disposal of Radioactive Wastes

a. All potentially contaminated materials should be considered radioactive unless a survey of the material reveals no contamination detectable with instrumentation of adequate sensitivity.
b. All radioactive waste must be placed of in appropriate waste containers approved by RSP. Liquid waste must be contained in tightly-capped plastic carboys which are only opened when actively adding waste. Attempts should be made to separate aqueous and organic radioactive wastes. The generation of mixed waste containing hazardous chemicals and radioactive material must be approved in advance by RSP and R&LSC. The generation of radioactive solid waste containing hazardous chemicals should be avoided entirely as disposal may be extremely expensive or impossible. No glass bottles are permitted for disposal of liquid wastes unless authorized by RSP.

Individual radioactive labels are to be removed or obliterated from waste material upon discard into labeled waste containers so that material later disposed of as exempt or decayed will not contain false radioactive warnings. Label all waste containers "Caution -- Radioactive Material" with the trefoil radiation symbol and record the radioisotope, quantity in microcuries, and date. Radioactive waste must be segregated by radioisotope. Prior permission of RSP is needed to generate waste containing more than one radioisotope.

c. In order to dispose of radioactive waste the PI or representative should contact RSP for pickup of the materials. Disposal of radioactive wastes without prior contact is not permitted. No one may enter the waste disposal room unless accompanied RSP. The authorized user is responsible for completing a Radioactive Materials Disposal Form and providing it to RSP at the time of waste pickup.

Note that no radioactive waste is to be released into the sewer system by laboratory personnel and no radioactive waste is to be incinerated. Empty laboratory containers must be thoroughly rinsed several times into liquid waste before washing. The efficacy of the rinsing protocol should be documented initially by scintillation counting the final rinse.

d. Scintillation vials are to be disposed of boxed upright. For radioisotopes other than ^{14}C or ^{3}H, separate vials containing radioisotope from wipe test vials containing little or no radioactivity.

4. Log Notebook

a. Each laboratory must maintain a laboratory notebook in which pertinent records are permanently filed and readily available. This notebook must be accessible to all persons who work with radioactive materials under the project. The notebook must include, but is not limited to, the following records:
    i. Correspondence with RSP and R&LSC.
    ii. Receipt, utilization, and disposal of each radioactive material, shipment, etc. It is essential that these records account for the difference between radioisotopes on hand and those received.
    iii. An inventory of radioactive materials on hand in the laboratory.
    iv. Instrument surveys and results of wipe tests for removable contamination --specify the date, the person making the survey, the instrument used, including serial number, model number and the location and levels of radiation and contamination encountered. Details of any contamination cleanup and after cleanup surveys. It is important that a statement regarding the average exposure reading encountered in work areas be included in the record even when this value is essentially background. Causes of high survey readings should be determined (with the assistance of RSP if necessary) documented and eliminated whenever possible.
    v. Results of any sealed-source leak tests pertaining to any sources in the laboratory.
    vi. Additional miscellaneous entries in the notebook should include the addition or deletion of personnel from the project staff, significant instruction or information programs carried out for or attended by students or technical assistants, and accidents or instances of contamination together with a description of corrective actions.

b. Inventory control forms must be filed with RSP whenever requested.

c. RSP must be notified at once whenever radioactive materials have been lost or misplaced.

D. RADIATION SURVEYS

Good laboratory practice dictates that radiation surveys be made during and after experiments and routinely thereafter to ensure that radioactive materials are adequately shielded and that contamination is controlled.

1. Instruments

Portable radiation detection instruments are commonly used to make radiation surveys and evaluate levels of contamination (except for ^{3}H contamination). Each laboratory which uses radioactive materials is responsible for possessing or having access to the radiation detection instrument which is appropriate for the radioactive material with which it works. RSP can assist in choosing the correct detector. Examples of common detectors include Geiger Mueller counters and ion chamber counters. Liquid scintillation counters are used to measure wipe surveys.

The manufacturer's instruction for use should be followed for detectors. RSP can assist if questions arise on proper operation. Detectors must be calibrated at least annually and whenever major changes/repairs occur. An un-calibrated detector should never be relied upon for surveys as contamination might be undetected and lead to unnecessary exposures.

2. Wipe Surveys

An effective method for surveying for removable contamination -- the only effective method of surveying tritium contamination -- is to take wipes in work areas, on floors, etc., using filter paper or cotton swabs. A series of wipes should be taken from those surfaces where contamination is likely or where radiation levels are high. This can include, but is not limited to, incoming packages, areas where solutions are prepared, pipetting is performed, organic synthesis undertaken, etc. The wipes should be numbered, labeled, and located on a sketch of the areas being examined. The wipes are rubbed over a surface area of ~100 square centimeters. Count the wipes in a suitable detection system (for ^{3}H, a liquid scintillation counter is usually the only suitable counter). The resulting counts give an indication of the levels of contamination. In keeping with the ALARA philosophy, detectable contamination should be promptly removed. If serious contamination, e.g., 50,000 dpm on a wipe, is found, call RSP for assistance.

Keep a record of results of surveys performed by the laboratory personnel in the laboratory notebook. RSP makes periodic surveys of all laboratories where radioactive materials are used and issues written reports. Special surveys may be requested when it is believed necessary.

3. Surveys required on transfer

Equipment used with radioactive materials must be surveyed before being transferred between laboratories, being transferred to surplus, or transferred for repair. Radioactive warning tags indicating radioisotope used should not be removed from equipment without wipe surveys documenting lack of contamination. For transfers to non-radioisotope using laboratories, to surplus, or off-campus, RSP should perform the surveys.

4. Leak tests on sealed sources

All nonexempt, licensed, sealed sources will be tested at six month intervals or as otherwise required. Testing will be conducted by a firm approved to do so by TX DSHS. Examinations are conducted to ensure that sources do not exhibit leakage in amounts greater than 0.005 µCi. If a suspected problem occurs with a sealed source, contact RSP and arrangements will be made to test the source immediately. All leaking sources will be properly disposed of by RSP.

5. Frequency of surveys

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

Low-Level Areas – At least once a month - Areas such as where in vitro tests are performed, samples analyzed, etc. (samples usually less than 100 microcuries each).

Medium-Level Areas – At least once a week - Areas where 100 microcurie to millicurie amounts of material are handled.

High-Level Areas – At least once a day - Areas used for storage of active solutions, preparation of materials, fume hoods, etc. (usually tens of millicurie amounts).

6. Acceptable Limits for Radioactive Contamination

Acceptable limits of contamination shall be as follows

a. In controlled areas specifically designated for use of radioactive material by users only and not frequented by members of the general public (non-users of radioactivity), the continuous dose rate outside of shielding shall be no greater than 0.2 mrem/hr and removable contamination on designated work area surfaces shall not exceed 1000 dpm/100 cm2 (beta-gamma) or 100 dpm/100 cm2 (alpha)
b. In uncontrolled areas accessible to the general public (non-users of radioactivity) and not specifically designated for radiation use, radiation levels shall not exceed 2 millirem in any one hour and 100 millirem per year. Both limits must be observed and documented. Removable contamination will not exceed 100 dpm/100 cm2.
c. In both cases calibrated instruments with known efficiency for the radiation being detected must be used.

E. STANDARD METHODS FOR REDUCING EXPOSURE AND CONTAMINATION

1. Storage of Radioactive Materials

Store all radioactive material in a place to minimize exposure.

Use adequate shielding -- exposure rate should not exceed 2 mR/hr at 30 cm from the shield. Include areas behind the shield, above and below when assessing exposure rates. Ensure a bench top will support the weight of a shield and that shielding materials are secured so that they will not fall.

Use a pan and/ or absorbent pad when using liquids to catch spills.

Clearly identify each item in storage as being radioactive by using the appropriate labeling.

Survey area periodically using an appropriate method.

Post storage areas with proper signage or labels.

Do not store food in areas (including refrigerators) where radioactive materials are stored.

Locate appropriate handling tools and supplies conveniently.

Store radioactive liquids in unbreakable containers or in secondary containers to prevent or contain spillage.

Shield radioactive wastes awaiting pickup so that radiation levels at 30 cm do not exceed 2 mR/hr.

2. Work Areas

Use absorbent pads or pans to cover work areas. Small, easily spilled containers need a stable work surface to prevent spills.

Good housekeeping is required where radioactive materials are used. Clean contaminated items as soon as possible. Change bench covering frequently enough to prevent external exposure from spots of contamination and to reduce airborne contamination from dried spills.

Provide adequate shielding to ensure radiation exposure rate is less than 2 mR/hr at 30 cm from shields. Survey periodically using appropriate methods. Make sure that a bench will support the required shielding and that the shield is secured so that it will not fall.

Do not keep foods or beverages where radioactive materials are present. Smoking, eating and drinking in laboratories is prohibited.

3. Handling

Wear appropriate personal protective equipment such as gloves, safety goggles and a laboratory coat when handling unsealed radioactive material. In some instances leaded aprons or other garments may be necessary or useful. Wear shoes which completely cover the feet.

Use remote or hand-controlled pipettes. Mouth pipetting with radioactive materials is prohibited.

Use appropriate containment, e.g. fume hoods or glove boxes, for handling radioactive materials that may become airborne, such as dusts or vapors. Where radioactive iodine vapors are present, always use a fume hood that has a minimum average face velocity of 100 ± 20 feet per minute at the sash opening.

Never work with radioactive materials with open cuts on the skin which may become contaminated.

Do not eat, drink, or smoke in areas where radioactive materials are used or stored.

Be informed; know the mechanical, chemical and radiation hazards of the materials and operations that are to be performed. Frequently, it is useful to try a dry-run experiment to see if a radioactive experiment is feasible.

4. Posting and Labeling Requirements

In certain instances, signs or labels are required for specific levels of radiation and radioactivity. Consult RSP for assistance in posting or otherwise controlling areas where radiation dose rates exceed 100 mR/hr, or where radioactive materials may be airborne. The following are some of the general requirements for signs and labels. Signs are usually available from RSP.

a. **"Radiation Area - Authorized Personnel Only"**. This sign is used in area in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 millisievert) in 1 hour at 30 centimeters from the source of radiation or from any surface that the radiation penetrates.
b. **"Caution -- Radioactive Material -- Surfaces and Items in This Area May Be Contaminated".** This sign shall be used to post work areas where radioactive contamination may be present, e.g., hoods, bench tops, and sinks, etc.
c. **"Caution -- Radioactive Materials"**. This label is required on any container in which radioactive materials (including waste) are transported or stored or, in some cases, used. The label must specify radioisotope, activity level, and dates measured. It must be posted where radioactive material is present and on the outside door of the laboratory using or storing radioactive material.
d. Radioactive Liquids and Radiochemicals in Storage. Vials or containers must bear a durable label stating radionuclide, original amount and assay date.
e. Experimental Apparatus and Glassware. Any apparatus that will contain significant radioactivity overnight either due to prolonged experimentation or contamination must be individually labeled with an estimate of the quantity of radioactivity present. Where containers are used transiently in laboratory procedures in the presence of the user, no individual labels are required, but a "Caution – Radioactive Material" sign should be placed so that it clearly indicates the presence of radioactivity. Radioactive materials must be contained in areas with proper signage.
f. Radioactive Waste. All radioactive waste containers shall bear appropriate signs or labels. Logs shall be completed showing an estimate of the radioactivity in the waste containers.
g. Notice to Employees. Conspicuously post a current copy of RC Form 203-1 ("Notice to Employees") in a sufficient number of places to permit individuals working in or frequenting any portion of a controlled area to observe a copy on the way to or from such an area (such as the laboratory bulletin board).

F. USE OF RADIOACTIVE MATERIALS WITH ANIMALS

1. All work shall be performed in rooms approved by the R&LSC and Institutional Animal Care and Use Committee (IACUC) and included on UTSA's Radiation License. These rooms must be marked by a warning tape bearing the radioactive symbol.
2. After a radioactive material has been introduced into an animal, its cage and equipment shall be marked by warning tape bearing the radioactive symbol. The name of the investigator, the radioisotope used, the quantity of radioactive material introduced into the animal (in microcuries), the date of exposure, and the route of exposure shall also be noted on the cage. The IACUC in conjunction with the R&LSC will review the procedures involving the use of radioactive materials in animals.
3. After radioactive materials have been introduced into experimental animals, each animal shall be identified. The cage, bedding, wastes, and in some cases the rack and the room must be recorded and treated as radioactive. This requires considerable care in the handling and disposal of equipment, waste, and animals.
4. It is the licensed PI's responsibility to have all radioactive waste (bedding, excreta, etc.) collected in approved plastic containers and surveyed for contamination. If contaminated, the waste is reported to RSP for disposal. All radioactive animal cadavers are to be tightly wrapped and placed in a freezer designated by RSP. Do not place animal cadavers directly into biological waste containers.
5. The PI is responsible for:
   a. Conforming to all regulations established by the IACUC.

b. Notifying Laboratory Animal Research Center (LARC) personnel that animals containing radioisotopes will be housed in their facilities.
c. Notifying RSP that animals containing radioisotopes will be housed in the Animal Care Facility and providing any additional information as requested.
d. Ensure that cages are decontaminated before returning them to LARC for cleaning.
e. Dispose of the carcass and bedding in accordance with the radioactive waste program.

G. DECONTAMINATION

Removal of radioactive contaminants falls into two categories: 1) decontamination of personnel and, 2) decontamination of facilities. The degree of contamination must first be determined by conducting a Radiation Survey consisting of a radiation level survey and/or a contamination level survey. If a radiation level survey in a controlled radiation work area of a laboratory shows a continuous dose rate outside of shielding greater than 0.2 mrem/hr or removable contamination greater than 1000 dpm/100 cm^2 (beta-gamma) or 100 dpm/100 cm^2 (alpha), decontamination is required. For areas of a controlled laboratory, other than those designated radiation work areas radiation levels must not exceed 2 millirem in any one hour or 100 millirem per year and removable contamination must be less than 100 dpm/100 cm^2 as demonstrated by wipe survey.

1. Personnel Decontamination

a. Prompt removal of surface contamination is necessary to prevent radioactivity from entering the body by ingestion, absorption, inhalation or through damaged skin and to prevent radiation overexposure of the skin. It is imperative that the methods used to carry out decontamination should not spread localized radioactive material or assist the contaminant in entering the body. Report personnel contamination to RSP immediately.
b. The following procedures have been used for removal of a wide variety of contaminants from personnel. (More drastic methods must be performed only under medical supervision.)
   i. Remove contaminated clothing and place it in a suitability labeled container.
   ii. Monitor the person carefully to determine the level and location of contamination.
   iii. Decontaminate in the following manner:
      a) Unless a large amount of radioactivity is involved (millicuries), carefully rinse the affected area with running water in a sink. Done quickly, rinsing can prevent possible absorption through the skin.
      b) For solid contamination, use masking or adhesive tape to remove loosely attached contamination. This can prevent spreading the material or absorption into the skin, as can happen if solvents are used.
      c) If there is a suitable solvent for the material which will not damage the skin utilize it to the remove the material.
      d) If the above methods fail, cleanse the contaminated areas with mild detergent and water -- giving special attention to hair and fingernails.
      e) If the contamination is localized, avoid spreading the contamination by general washing.
      f) If the procedures outlined above fail to remove the contaminants, soft brushes may be used for cleansing, but care must be taken to avoid use of abrasive or strongly alkaline cleansers that may allow the contaminants to penetrate the skin.

g) Another technique that can be used to remove radioactive contamination from the skin is using a potassium permanganate solution (or a mixture of saturated potassium permanganate and a 1 percent solution of sulfuric acid) poured over the contaminated area and rinsed thoroughly under running water. (Consult RSP before applying).
h) If skin contamination cannot be easily removed in several attempts notify RSP and seek medical attention.
i) RSP will perform nasal wipes for later investigation if contamination is due to an airborne source.

If the contaminated individual also requires medical treatment, do not delay treatment. Provide information and assistance, if requested, to the medical caregivers to prevent the further spread of any contamination from the individual. Decontamination can proceed after the individual is treated or stabilized.

2. Facility Decontamination

a. Survey to determine the level and location of contamination.
b. Post appropriate signs to keep people out of area.
c. Mark off contaminated areas (masking tape is useful for this purpose).
d. d. Plan the specific decontamination procedure prior to taking action. Obtain an adequate supply of decontamination materials. Consult RSP as needed.
e. Cover clean areas with paper or plastic sheeting to prevent spread ofcontaminants, if the situation merits such action.
f. Wear personal protective equipment such as rubber gloves, shoe covers and respirators as appropriate.
g. First remove "hot" spots, then work from the perimeter toward the center. Do not use excessive water since this may cause the contamination to run off.
h. Take care not to track contamination. Monitor all persons leaving the contaminated area -- particularly check soles of shoes and hands.
i. Isolate and retain mops, rags, brushes, and wash solutions until these can be surveyed for contamination.

3. Techniques

Techniques for removal of contamination from facilities are generally subject to consideration of the value of the contaminated items and the durability of the contaminated surfaces. A summary of techniques that have been successfully employed in decontamination of various materials follows.

a. <u>Tools and Glassware -</u> Decontamination methods fall into two broad classifications: corrosive and non-corrosive. It is always desirable to use a non-corrosive method, yet this is seldom practical, since removal of the surface layers of material is more effective in putting ions back into solution than the very slow process of ion exchange or desorption by non-corrosive methods.
   i. Noncorrosive: Clean with an aqueous solution of a mild dishwashing detergent. This should be tried before other methods. Since some elements, such as iodine, will become volatile when reacted with acids, only noncorrosive methods should be used when these elements are present.
   ii. Corrosive: Wash with acid (chromic acid cleaning solution or dilute nitric acid) and rinse with water. The use of acid on metal tools may corrode them causing greater difficulty in future decontamination procedures. Metal objects may be decontaminated with dilute mineral acids (nitric), a 10 percent solution of sodium citrate or ammonium bifluoride. When all other

procedures fail for stainless steel, use hydrochloric acid. This is a good decontaminant, for the reason that it removes some of the surface; however, this procedure results in etching of the stainless steel, which makes it less desirable for future use. Glass and porcelain articles may be cleaned with mineral acids, ammonium citrate, trisodium phosphate, cleaning solution (chromic acid) or ammonium bifluoride. When the glaze is broken on porcelain, or when active solutions are heated to extreme dryness in glass, decontamination is very difficult, and usually it is more convenient to replace items.Plastics may be cleaned with ammonium citrate, dilute acids or organic solvents.

iii. Over the counter decontamination solutions are advisable, such as No-count contamination spray.

Equipment - that is found to be contaminated after the initial treatment shall be stored in an isolated location, such as, in a properly labeled hood with adequate exhaust until more thorough decontamination procedures may be applied. If it is necessary to dismantle any equipment prior to decontamination procedures, careful survey should be made during the operation. Contaminated equipment shall not be released from control of the laboratory for repair, or any other purpose, until the level of activity has been reduced to a safe limit. Where the half-life of the contaminating element is short, it may be desirable to store tools and glassware for decay of activity rather than to attempt decontamination of them. In many cases, if the items are cheap or easily replaced, it may be simpler to dispose of such equipment in a recommended manner and replace with new equipment.

Equipment that is contaminated with long-lived isotopes and that cannot be satisfactorily decontaminated, must be regarded as radioactive waste and disposed of in a proper manner.

Glassblowing, welding, brazing, soldering, etc., should never be permitted on equipment contaminated with radioactive materials unless it is done in special ventilated facilities, and special techniques are used to prevent the inhalation of radioactive dust and fumes.

It should be noted that the effectiveness of a decontaminating process is, for all practical purposes, complete at the end of the second repetition of the process. If necessary, other methods should then be considered for further decontamination.

Laboratory equipment should be surveyed for residual contamination following decontamination procedures. Decontamination seldom exceeds 99.9 percent efficiency and usually is considerably less efficient. If the residual contamination indicates that the level of activity is still greater than that specified as permissible then the equipment shall be regarded as radioactive waste.

b. Floors and Benches. Clean carefully as described below, using caution not to spread contamination. Use masking or adhesive tape to remove loose dry contaminants. For wet contaminants, use absorbent material such as paper towels, "Kimwipes", disposable diapers, or tissue. The following steps can then be used:
   i. Use a mop with water or with water and detergent.
   ii. If mopping will not remove the contamination, proceed with a method suitable for the particular surface material. Consult RSP before employing any of the following methods. Linoleum may be decontaminated by carbon tetrachloride, kerosene, ammonium citrate solution or dilute mineral

acids. Care should be taken not to dissolve sealing compounds at the edges and between cracks of the linoleum. Ceramic tile may be decontaminated by the use of mineral acids, ammonium citrate or trisodium phosphate solutions. Paint is sometimes successfully decontaminated by carbon tetrachloride or 10% hydrochloric acid; however, danger of dissolving the paint exists, and it is preferable to remove the paint and apply new coatings. With contaminated concrete, the surface can be removed using hydrochloric acid. Contaminated wood surfaces may need to be planed. For deeper contamination of surfaces consult RSP.

iii. Detergents or wetting agents may be used for the decontamination of strippable plastics on polished stainless steel, glass or other smooth impervious laboratory surfaces.

iv. Sinks, traps, and drains may be decontaminated by the following procedures:
   a) Flush thoroughly with a large volume of water.
   b) Scour with a rust remover and flush thoroughly.
   c) Soak in a solution of citric acid prepared by adding 1 pound of acid to 1 gallon of water and flush thoroughly.

If contamination is not satisfactorily reduced after several attempts, it may be possible to cover a surface and/or add shielding to reduce high exposure levels until the radioisotope has decayed or a practical removal method devised. Such covered areas of contamination should be appropriately labeled and adequately documented in facility survey records.

APPENDIX A – GLOSSARY

The following is a list of some of the terms and units that are basic for understanding and applying principles of radiation protection.

Alpha particles are equivalent in mass to helium nuclei. They are emitted primarily during decay of heavy radionuclides including uranium, thorium, radium, and elements in the trans-uranium series. The energies for alpha particles emitted from typical radionuclides are in the 3-6 MeV range. Alpha particles, because of their large mass, have a relatively low velocity. This velocity and the double positive charge mean that alpha particles interact strongly with matter, producing intense ionization as they dissipate their kinetic energy in very short distances. In general, alpha particles can travel only short distances (3 inches) in air and can be stopped by a thin sheet of paper or the dead layer of skin. When radionuclides that emit alpha particles become deposited within a person's body, those cells within a fraction of a millimeter of the site of deposition will receive very large doses of radiation.

Beta particles are emitted from the nucleus and are identical to orbital electrons in mass and charge. As the result of the emission of a beta particle (negative), a neutron is converted to a proton in the nucleus so that the atomic number is increased by one. The atomic mass number remains the same. Beta particles are more penetrating than alpha particles. Beta particles are emitted in a spectrum of energies; the average energy is 1/3 of the maximum.

Bremsstrahlung is electromagnetic radiation (like x-rays) produced when charged particles decelerate in matter. The production of bremsstrahlung depends directly upon the energy of the particle and the atomic number of the absorber.

Curie. The curie (abbreviated Ci) is the unit that describes the quantity of radioactivity, i.e., the number of nuclear transformations (or disintegrations) per unit time. One curie of activity equals 3.7 x 1010 nuclear transformations per second. The curie is a relatively large unit; most of the quantities of radioactivity used on campus are at the millicurie (mCi) or microcurie (µCi) level (i.e., 1/1,000th or 1/1,000,000th of a curie, respectively).

Electron volt is a small unit of energy used to describe radiation energies of individual particles or rays. One electron volt equals 1.6 x 10-19 Joule and is the kinetic energy an electron would have after being accelerated through a potential difference of 1 volt. The maximum beta energies of 3H, 14C, and 32P are respectively 18.6, 156, and 1700 keV (1 keV = 1 thousand electron volts).

Gamma rays and x-rays are part of the electromagnetic energy spectrum that also includes radio waves, visible light, and ultra-violet light. X-Rays and gamma rays have very high energies, short wave lengths and readily penetrate matter. Gamma rays and x-rays differ only in their source. Gamma rays arise from the atomic nucleus while x-rays arise from orbital electron energy transitions. Both of these radiations interact with matter mainly by transferring energy to orbital electrons causing ionization. Dense materials with high atomic numbers, such as lead, make the best shields against these radiations.

Half-life. The half-life of a radionuclide is the period of time required for half of the atoms in a sample of that radionuclide to undergo nuclear transformation decreasing the activity by one-half.

Half-value layer. The thickness of a specific shielding material required to attenuate 50% of the radiation of a given x-ray or gamma ray emitter. The half-value layer thickness depends on the density of the shielding and the energy of the emitter.

Ionization is the process by which a neutral atom or molecule acquires a positive or negative electrical charge.

Linear energy transfer is the linear density at which energy is deposited along the track of a particle or ray, usually expressed in keV per micron. Particles such as protons, neutrons, and alpha particles have much higher rates of linear energy transfer than gamma rays, x-rays, or electrons and consequently do more biological damage and are assigned a higher quality factor for overall energy dose delivered to tissue.

Neutrons are electrically neutral particles. They may be produced from nuclear interaction when high-energy particles interact with nuclei or by fusion. Neutrons are the only particles able to render other materials radioactive.

Positrons are positively charged beta particles (equivalent in mass to electrons). They are emitted from the nucleus in the same manner as negatively charged electrons. The process results in a proton being transformed into a neutron. The resulting nucleus will have one less positive charge and the same mass number as the original nucleus. Positrons are emitted in a spectrum of energies. When the positron collides with a negative electron both particles are annihilated. The masses of the positron and electron are totally converted to energy in accordance with formula, E = mc2, two photons with energies of 0.511 MeV are produced. The annihilation radiations have the same characteristics as gamma rays.

Quality factor (QF) is a number by which absorbed doses are multiplied to obtain dose equivalent for radiation protection purposes. It is a quantity that expresses on a common scale the radiation harm incurred by exposed persons.

Rad is the unit of absorbed dose. One rad is the dose when any ionizing radiation deposits 100 ergs per gram in any material. Since one R of exposure in the energy range of 0.1 to 3 MeV dissipates 87 ergs per gram of air (or 96 ergs per gram in soft tissue), the units are said to be nominally equivalent.

Rem is the unit of dose equivalent that is used for radiation protection purposes. It is the product of the absorbed dose and a factor that relates it to the harmfulness to man. This latter factor is termed the Quality Factor.

Roentgen, R, the unit of exposure, is the amount of x-ray or gamma radiation that will produce one esu of charge per cc of air at standard temperature and pressure.

X-rays (see gamma rays).

APPENDIX B – GAMMA DOSE RATE CONSTANTS FOR SELECTED NUCLIDES

Table 1. Gamma dose rate constant (Γ) for selected nuclides.

Nuclide	Γ	Nuclide	Γ	Nuclide	Γ
Antimony-124	9.8	Indium-111***	3.24	Rubidium-86	0.5
Barium-133	2.4	Indium-113m***	1.77	Scandium-47	0.56
Beryllium-7	0.3	Indium-114m	0.2	Selenium-75	2.0
Bromine-82	14.6	Iodine-123***	0.67	Silver-110m	14.3
Carbon-11**	5.9	Iodine-125***	1.5	Sodium-22	12.0
Cesium-137	3.3	Iodine-131	2.2	Sodium-24	18.4
Chromium-51	0.16	Iridium-192	4.8	Strontium-85	3.0
Cobalt-57	0.9	Iron-59	6.4	Tantalum-182	6.8
Cobalt-60	13.2	Manganese-54	4.7	Technetium-99m	0.7
Copper-64	1.2	Mercury-203	1.3	Thallium-170	0.025
Gallium-67	1.1	Molybdenum-99	1.8	Tin-113	1.7
Gallium-72	11.6	Potassium-42	1.4	Xenon-133	0.14
Gold-198	2.3	Potassium-43	5.6	Zinc-65	2.7
Radium-226	8.25				

References

*Jaeger, R.C., et al., Engineering Compendium on Radiation Shielding, Vol. 1, (New York:Springer-Verlag, 1968), pp 21-30.

Γ is given in R-cm2/hr-mCi = 10× Γ in units of R-m2/hr-Ci (see below)

**A Manual of Radioactivity Procedures (National Bureau of Standards Handbook No. 80 (Washington, D.C.: Supt. of Docs., U.S. Government Printing Office, Nov. 1961), Appendix A, pp. 137-140.

***Stanford University, Health Physics

In order to derive the exposure rate in terms of R per hour per curie at one meter, the above Γ values in the table should be divided by 10.