Rice University
Radiation Safety Manual

Environmental Health and Safety
MS 123
P.O. Box 1892
Houston, TX 77251-1892

October 2017

INTRODUCTION

The goal of the Radiation Safety Manual is to assist lab management and personnel in complying with regulations put forth by the Texas Department of State Health Services Bureau Radiation Control (DSHS-BRC) and Rice University. This manual is not intended to be a fully comprehensive reference. Further advice concerning hazards associated with specific radioactive substances, devices and the development of new or unfamiliar protocols should be obtained through consultation with the Department of Environmental Health and Safety.

REFERENCES

Texas Department of State Health Services Bureau Radiation Control (DSHS-BRC)
http://www.dshs.state.tx.us/radiation/default.shtm

SCOPE

This program is applicable to all laboratories, research, service and support activities at Rice University that use radioactive materials and energized equipment including x-ray producing devices.

RESPONSIBILITIES

Radiation Safety Officer (RSO) – The RSO is responsible for administrating this Radiation Safety Program with duties including but not limited to the following:

- Conducts preliminary review for RAM activities.
- Oversee the daily management and implementation of the Radiation Safety Program.
- Has the authority to stop any radioactive work deemed a hazard to employees, the public, or the environment.

Environmental Health and Safety – EHS is responsible for audits in compliance of the Radiation Safety Program including but not limited to the following:

- Review of current registration for compliance.
- Identify work area hazards and approve proper personal protective equipment.
- Provide General Radiation Safety Training.
- Evaluate and update the programs as needed.

Principle Investigator – PIs are responsible for the safe use of radioactive material and radiation producing devices under their authorization with following requirements.

- Provide laboratory specific training for all students and staff required to use radioactive materials and energized equipment including x-ray devices.
- Notify the RSO of any new radiation sources.
- Notify the RSO if any radiation sources are transferred, received or removed from use.
- Ensures good laboratory practices with emphasis on safety.

Authorized Users – Authorized users are responsible for conducting their experiments in a safe manner by following all applicable radiation safety rules and regulations.

- Everyone who anticipates working with radioactive materials must attend formal radiation safety training provided by EHS.

DOSE AND EXPOSURE

Occupationally Exposed Adults Workers

The NRC dose limit for occupationally exposed adults are listed in Table 1.

Dose Limit	Annual Limit	
	rem	Sv
Total Effective Dose Equivalent (TEDE)	5	0.05
Lens Dose Equivalent (LDE)	15	0.15
Total Organ Dose Equivalent	50	0.50
Shallow Dose Equivalent (SDE)	50	0.50

Table 1: Limits based on values listed in 25 TAC 289.202(f)

Minors

Students under the age of 18 must obtain approval from the RSO to work with RAM. The annual dose limits for minors are 10 percent of the annual dose limits specified for adult workers

Pregnant Workers

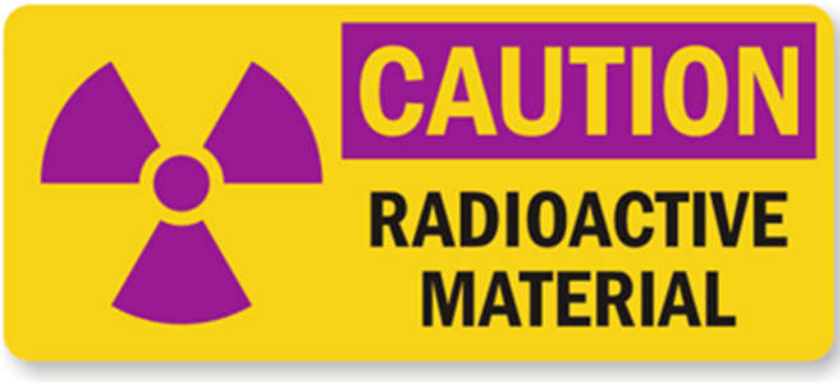
The NRC dose limit to the fetus of a declared pregnant woman is 500 mrem (10% of the occupational dose limits for adults) in one calendar year or 50 mrem in one calendar month. If you are pregnant or believe you may be pregnant contact the RSO. All inquiries will be kept in confidence. We will take the following steps:

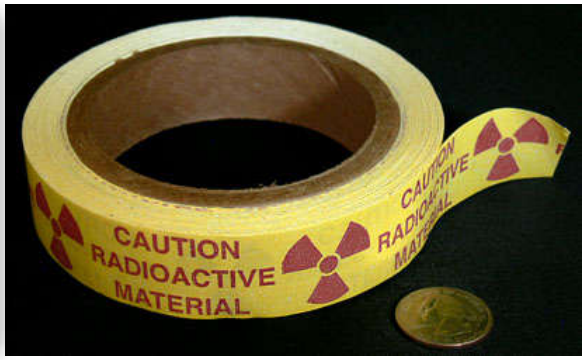
1. Provide an opportunity to declare your pregnancy.
2. Evaluate your dose history and exposure potential.
3. Provide you with information concerning risk.
4. Provide suggestions for reducing exposure.
5. Monitor your radiation dose with respect to the NRC limits.

Individual Members of the Public

The total effective dose equivalent to individual members of the public is limited to 100 mrem in a calendar year.

POSTING REQUIREMENTS





Room Requirements

1. Each room that is approved for the use or storage of RAM must be posted with, "CAUTION RADIOACTIVE MATERIAL".
2. Room signs are provided by EHS. Laboratories where RAM is used or stored shall post a "Notice to Employees" (RC FORM 203-1) signage visible for all employees and visitors. This form is available for download at the EHS website.

Work Stations Requirements:

1. When possible, RAM use should be restricted to specific, labeled RAM work stations within the lab that are labeled with "CAUTION RADIOACTIVE MATERIAL" tape.
2. Surfaces and pieces of equipment located within a labeled work area should be considered contaminated until an appropriate survey of the area determines otherwise.
3. Individuals working at a labeled work station must wear personal protective equipment (lab coat, gloves, safety glasses).

Container Requirements:

Individual containers of RAM must be labeled with "CAUTION RADIOACTIVE MATERIAL" tape unless properly decontaminated and surveyed. The label should indicate:

1. Type of radionuclide
2. Estimate quantity of radioactivity and date
3. Any other hazard information to the use of this material

Equipment Requirements:

The following equipment must be labeled with "CAUTION RADIOACTIVE MATERIAL" tape.

1. Fume hoods, refrigerators, cabinets etc. used to store RAM
2. Centrifuges, pipettes, water baths, etc., that are used for RAM work must be labeled unless they have been decontaminated.

Protocols involving radioactive materials should be performed with equipment should dedicated for RAM work only. This equipment should not be used to perform any other experiments unless it is decontaminated and surveyed prior to use.

Lab Waste Requirements:

All radioactive waste containers must be labeled with "CAUTION RADIOACTIVE MATERIAL" tape and a label indicating the isotope contained. EHS will provide labeled waste containers. Make sure that radioactive warning labels are clearly affixed to any container used for radioactive specimens, waste, sharps containers, etc.

ORDER AND RECEIVING RAM

Obtaining approval

All radioactive material received in the lab must be approved by EHS before the order is placed.

1. Approval may be obtained through the RAM Order Approval form in Appendix B.

Each stock vial, sealed source, standard, marker, etc. must have its own unique inventory number. For example, if you are ordering 2 x 0.250 mCi of P-32, you should make two entries.

The RSO will ensure that the total on-hand radioactive material inventory remains within the activity limits authorized under the Radioactive Material License.

Placing the order
After approval has been granted by the RSO, the authorized user may purchase the RAM within the scope of that specific authorization. The authorized user must notify the RSO of the intended order and receipt of radioactive material.

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

1. Name of Principle Investigator and contact information
2. Type of radioisotope
3. Chemical form and compound
4. Activity per vial, total number of vials, and total activity of the order
5. Vendor name
6. Any additional information

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

** Use the shipping address that corresponds to your physical location**

Main Campus (L01772):

Environmental Health and Safety
Rice University
6100 Main Street
Houston, TX 77005
Attn: (Primary Investigator) c/o Chris Mize
713-348-4444

BRC (L06284):

Environmental Health and Safety
Rice University BRC
6500 Main Street
Houston, TX 77030
Attn: (Primary Investigator) c/o Chris Mize
713-348-8801

Each supplier of radioactive material is required by state and federal regulations to validate Rice University license to possess and to use such material. The RSO will arrange for copies of the license to be made available to the supplier if need.

Receiving
Radioactive material shipments are reviewed and processed by the RSO or a designee. Packages are inspected for contamination and recorded on the Radioactive Material Package Receipt and Delivery Form (Appendix H).

Packages shall be monitored no later than 3 hours after receipt if receieved during normal working hours. If the package is receieved after working hours, the package shall be monitored no later than 3 hours from the beginning of the next working day. If the package is damaged (crushed, wet, etc.) it shall be surveyed

immediately. The contents will be considered to be contaminated if readings exceed 2x background. Action will be taken against the shipper at this point and the package will not be delivered to the lab.

After determination that the external surfaces of secondary containers are not contaminated, applicable radioactive material markings will be defaced or obscured. Notification is relayed to the listed contact person that the material has arrived and will be delivered to the lab.

Authorized users will sign, date, and take possession of the inventory form upon receipt of the package. This form will be maintained by the laboratory personnel. In special circumstances, radioactive material shipments may be received directly at laboratories. If this is the case, arrangements must be made with the RSO.

Opening RAM Packages
Put on lab coats, safety glasses, and gloves before opening the outer package. Examine the package to ensure that it is not damaged or leaking. Survey the external surface of the shipping container (box) for contamination.

Open the inner package to verify the contents and check the integrity of the final source container (inspect for evidence of breakage, loss of liquid, discoloration of packaging, etc.).

Monitor the package and the packing material for contamination. If there is no contamination, obliterate all radiation labels and discard the packaging in regular trash

INVENTORY AND SECURITY

An inventory and accountability system must be maintained. The inventory should enable you to track incoming shipments of material and account for its use, transfer, and disposal. Standard forms for documenting inventory are in Appendix E.

A. Receipt Log
Receipt records must include the following:

1. radionuclide
2. date of receipt
3. initial activity
4. amount of each withdrawal from the stock vial
5. date of final stock vial disposal

B. Semi Annual Inventory
An inventory of RAM on hand in the lab is required on a semiannual basis. The activity on hand for each radionuclide should not exceed the licensee's possession limit for that radionuclide. Please use the Semi-Annual Unsealed Source Inventory Report (Appendix E).

To complete your semiannual inventory:

1. Dispose of any material no longer useful to your research and record the disposal date on the receipt log.
2. Perform a physical check of all remaining stock vials/sources in the lab. There should be a one to one correlation between the sources on the receipt log without a disposal date, and the sources in the lab.
3. Sum the activity on hand for each isotope.

Laboratory Security
Access to radioactive material must be controlled so that unauthorized persons do not have access to the licensed material. Stored radioactive material must be secured within the lab.

SEALED SOURCES

Sealed sources are to be inventoried on a Semi-Annual basis. The Curium-244 source will be leak tested in accordance with 289.201(g). All other sealed sourced do not require leak testing.

LABORATORY MONITORING

Labs should be checked for contamination after each use of RAM and monthly for labs who actively use unsealed radioactive material. Include areas of potential radioactive contamination such as bench tops, the floor, telephones, doorknobs, faucet handles, freezer/refrigerator handles, etc. during routine monitoring. Any reading above 2x background will be considered contaminated and must be cleaned until readings are indistinguishable from background. Appendix F of this manual can be used for this purpose.

Monitor all facilities and equipment (liquid scintillation counters, centrifuges, pipettes, refrigerators, fume hoods, RAM sinks, etc.) used with RAM prior to being returned to non-controlled use and before performing any maintenance or repair work.

Survey meters may be used in areas where only gamma emitters (eg. I-125) or energetic beta emitters (eg. P-32) are used. Wipe tests must be used to check for contamination in labs using RAM that cannot be easily detected with a survey meter (eg. H-3, C-14).

Use of survey meters:
Prior to use, assure that the instrument is functioning by performing a battery test, checking the background reading, and still within the calibration date. Verify that the meter and probe are appropriately sensitive for the isotope being monitored. Use a low-energy gamma scintillation probe for I-125; a pancake probe for energetic beta emitters like P-32.

To perform a survey, move the meter/probe slowly over the surface you are monitoring. Keep the face of the probe parallel to the surface, and as close as possible without contaminating the meter.

Performing a wipe test
Put on gloves, safety glasses, and lab coat. Drag the "wipe" over the surface to be tested applying moderate pressure and covering approximately 100 cm2. The wipe can be a q-tip or filter paper wetted in ethanol.

Count the wipes in a liquid scintillation counter. Include one "blank" sample to verify that the background reading on the counter is consistent. If the wipes are more that 3x the value of your blank of “background” sample, the wipe is considered contaminated.

Records must include:
1. a map of the lab including the areas surveyed with sample ID numbers.
2. date of the survey
3. initials/name of the person performing the survey
4. survey instrument used
5. background reading in cpm

6. survey results for each area in cpm.

Forms for recording survey results can be downloaded from the EHS website and are in the appendices of this manual.

Positive Monitoring Results
If a reading value is more than 3x the value of your blank or "background" sample, the wipe is considered contaminated and must be corrected. Following decontamination, perform a resurvey until the sample values are indistinguishable from background. For widespread contamination or personnel contamination, contact EHS immediately.

PERSONAL MONITORING

External Dosimetry
Personnel dosimeters are devices worn to measure external radiation doses. State regulations require the use of monitoring devices for:

1. Adults likely to receive in one year from sources external to the body a does in excess of 10% of the regulatory dose limit
2. Minors likely to receive, in one year from sources of radiation external to the body, a deep dose equivalent on excess of 0.1 rem, a lens dose equivalent in excess of 0.15 rem, or a shallow dose equivalent to the skin or to the extremities in excess of 0.5 rem
3. Declared pregnant women
4. Individuals working in a high radiation area.

Dosimeters will be issued as needed. EHS provides dosimeters to workers in need of dosimetry. Dosimeters can be requested by contacting EHS.

Whole body dosimeters should be worn between the waist and shoulders, with the name plate facing away from the body. Rings should be worn under gloves and with the surface if the detection material facing the palm. When not in use, dosimeters must be stored in a low background area such as an office and not taken out of the building.

All personnel monitoring results are maintained by EHS and are available at your request.

Internal Dosimetry
When using radioactive material, accidental intakes may occur. This can happen as a result of a spill or loose surface contamination, or as a result of using volatile radioactive materials. Routine thyroid bioassays are required for iodinators, and urine bioassay for users of larger quantities of H-3. Although unlikely, a bioassay may also be requested by EHS in response to a spill or personnel contamination.

WASTE DISPOSAL

Radioactive wastes, depending on the physical form or make-up, are processed differently. The most difficult and expensive waste to dispose of is called "mixed waste" containing radioactive waste commingled with hazardous chemicals or biohazard waste. Whenever possible, limit the creation of these problematic mixed wastes. Contact EHS if you think you will be creating a mixed waste so that options can be discussed.

Segregation by Physical Form
Note: Radioactive waste must be segregated by both physical form and radiological half-life as described below.

Liquids
Liquid waste must not contain any solid objects such as tips or filter papers. Do not mix aqueous and organic-based solutions. This produces a "mixed-waste" which can be difficult to dispose of properly. Waste containers must be capped when not immediately "in-use" and stored within secondary containers at all times.

Liquid scintillation vials are a common enough waste that they are collected without needing to be poured into a liquid waste container. Collection boxes lined with double plastic liners can be obtained from EHS. Do not empty the individual vials. Only vials with scintillation cocktail may be placed in these containers. **NO** plastic bags, vial flats, test tubes, Ependorf tubes, or any other waste may be placed in these containers.

Solids (Dry Wastes)
"Dry" or "solid" wastes include paper, plastic, unbroken glass (no Pasteur pipettes), and gels. Items such as absorbent pads, disposable gloves, source vials, and plastic pipette tips can be disposed of in a "dry waste" container. No pourable liquids are allowed in dry waste containers. Tubes, bottles, and vials must be emptied of their contents before being placed in the dry waste container. Lead (in containment vessels or shields) is a hazardous material and as such must not be placed into a dry waste container. Serological pipettes are considered dry waste.

Radioactive sharps are any objects that might puncture human skin such as Pasteur pipettes, needles, broken glass, razor blades, etc. These materials must be placed in puncture-resistant, leak-proof containers. Never use a biological sharps container to collect radioactive sharps to avoid confusion. EHS supplies yellow sharps containers for this purpose.

Mixed Wastes
Mixed wastes are wastes that meet the legal definitions of both hazardous (based on chemical properties) and radioactive material and can be very difficult if not impossible to dispose. Avoid the generation of mixed wastes that contain long-lived radionuclides (half-lives >90 days).

Radioactive, infectious waste must be rendered noninfectious before EHS can pick up the waste. Special autoclave bags are available for handling this type of waste. Common disinfectants such as bleach may be sufficient for this purpose. Call EHS for instructions on how to handle infectious, radioactive waste.

Segregation by Radioactive Half Life
Along with the physical segregations discussed above, each radionuclide should be collected separately. This is required because short lived nuclides such as 32P can be "held for decay in storage". This means that the waste can be kept in a storage area, resurveyed after a set period of time, and if no radioactivity can be detected it can be disposed of as regular trash. Since only some radionuclides can be "decayed" for disposal purposes, and those that can decay at differing rates, it is important that laboratories properly segregate their wastes.

TRANSPORTATION

Transportation of Radioactive materials shall be hand carried to all locations. If transported from one building to

another, it shall be carried in a sealed container with a secondary container including absorbent material. Radioactive material shall not be transported from the BRC (6500 Main) to the BRC (6100 Main) or back unless it is by a contractor or certified shipper.

EHS will dispose of radiation waste in accordance with appendix J of this manual

ALARA

ALARA stands for As Low As Reasonably Achievable. The principles of this program are detailed below.

1. Time - Decreasing the amount of time spent in radiation fields.
2. Distance – Increasing the distance from the source. Exposure follows the inverse square law. Therefore if you double your distance, you will receive a quarter of the dose of the source.
3. Shielding – Using the appropriate shielding will protect you from radioactive sources.
4. Amount – decreasing the amount of unsealed radioactive material per experiment will result in a lower overall occupational dose.

Methods to follow this program include wearing a lab coat and gloves, not storing radioactive material with food, not eating or chewing gum in the laboratory, no mouth pipetting, monitoring your hands or other potentially contaminated surfaces, performing dry runs of your experiment, using the proper shielding, reviewing your protocol to determine if you can use less RAM per experiment.

Training and Communication

New Employee Training - Before beginning work in the lab, individuals who use radioactive material must attend EHS training and receive training from their principle investigator.

Annual Training held by EHS
Each calendar year, all persons who work in or frequent labs where RAM is used or stored must attend Annual Radiation Safety Training.

Training held by Principle Investigator (PI)
In addition to EHS training, each PI or the individual with primary supervisory responsibility must hold an in-lab training session to review their experimental protocols, work habits, and available safety equipment for adherence to the ALARA policy. Documentation of an ALARA training session is required. The topics covered, the date, and the names of attendees must be recorded and available in the lab's records. Standard forms for documenting ALARA training can be downloaded from our website and is Appendix I of this manual.

The topics for this training must include, but are not limited to, the following:

1. Location of all permit paperwork, including access in the absence of the permit holder.
2. Permit review including approved nuclides, limits, laboratories, users, and any other restrictions.
3. Locations of required signs, notices, and EHS Radiation Safety Manual.
4. Where radioactive material is used within the lab(s) and restrictions on that use.
5. Storage location(s) and procedures for radioactive material security and storage.

6. Radioactive material waste segregation and disposal forms and inventory forms properly signed and dated.
7. Review of written protocols involving radioactive material.
8. Radiological safety considerations and potential for the generation of airborne radioactive material.
9. Special handling techniques which will minimize exposure when handling radionuclides.
10. Instruct trainee on the proper use of survey equipment and techniques.
11. Frequency for both routine and post operational surveys as applicable to your laboratory.
12. Availability of appropriate personal protective equipment and a discussion of its importance.
13. Emergency procedures including contact numbers, spill response instructions, and locations of eyewash stations, safety showers, and spill kits.

Training for X-Ray Device users:
Each individual must receive training by the X-Ray device owner and by EHS before using an X-Ray Device. This training is separate from other radioactive material training. More information for this training can be found on our website.

All records must be maintained according to the Texas Department of State Health Services Bureau Radiation Control (DSHS-BRC), and standard operating procedures with a training acknowledgement log sheet should be readily accessible for inspection.

Definitions

Note: The Texas Regulations for the Control of Radiation (TRCR) Section 11.2, has a comprehensive set of definitions relevant to the license and to properties of radiation.

Becquerel (Bq): A S.I. unit of activity is the becquerel (Bq), which is defined as 1 atomic transformation (disintegration) per second.

Curie (Ci): A unit of measurement of radioactivity. One curie is that quantity of radioactive material which decays at the rate of 3.7 X1010 disintegration per second (dps). Commonly used sub-multiples of the curie are the millicurie (mCi) = 3.7 X107 dps (2.22 X 109 disintegration per minute (dpm) and the microcurie(μCi) = 3.7 X104 dps (2.22 X106 dpm).

Dose: as used in the TRCR rules means absorbed dose or dose equivalent as appropriate:

Absorbed dose: The energy imparted by ionizing radiation per unit mass of irradiated material at the place of interest. The special unit of absorbed dose is the rad. (See “rad”).

Dose equivalent: The quantity that expresses on a common scale for all radiation a measure of the postulated effect on a given organ. It is defined as the absorbed dose in rads times certain modifying factors. The unit of dose equivalent is the rem. (See “rem”).

Exposure: The absolute value of the total charge of the ions of one sign produced in air when all the electron (negatrons and positrons) liberated by photons in a unit mass value of air are completely stopped in air. The special unit of exposure is the roentgen. (See “roentgen”).

Grey (Gy): S.I. unit of absorbed dose which is equal to 100 rad.

High radiation area: Any area, accessible to individuals, in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirems.

Ionizing radiation: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter. Ionizing radiation includes gamma and x-rays, alpha and beta particles, high speed electrons, neutrons, and other nuclear particles.

Occupational dose: The exposure of an individual to ionizing radiation:

1. in a restricted area, or
2. in the course of employment in which the individual's duties involve exposure to ionizing radiation provided that occupational dose shall not be deemed to include any exposure of an individual to ionizing radiation for the purpose of diagnosis or therapy of the individual.

Rad: The special unit of absorbed dose. One rad = 0.01 joule/kg (100 ergs/g) or material. (See "Absorbed does").

Radiation: One or more of the following:

1. gamma and x-rays; alpha and beta particles and other atomic or nuclear particles or rays;
2. stimulated emission of radiation from any electronic device to such energy density levels as to reasonably cause bodily harm; or
3. sonic, ultrasonic, or infrasonic waves from any electronic device or resulting from the operation of an electronic circuit in an electronic device in the energy range to reasonably cause detectable bodily harm.

Radiation area: Any area, accessible to individuals, in which there exists ionizing radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 millirems, or in any five consecutive days (40 hours) a dose in excess of 100 millirems.

Radiation safety officer (RSO): One who has a knowledge of and the responsibility to apply appropriate radiation protection rules, standards, and practices; official licensed by the state of Texas to supervise all aspects of the license.

Rem: The special unit of dose equivalent. One millirem (mrem) = 0.001 rem. For the purpose of the TRCR rules, any of the following is considered to be equal to 1 rem:

1. an exposure of 1 R (roentgen) of x or gamma radiation;
2. an absorbed dose of 1 ad due to x, gamma, or beta radiation;
3. an absorbed dose of 0.05 ad due to particles heavier than protons and with sufficient energy to reach the lens of the eye; or
4. an absorbed dose of 0.1 rad due to neutrons of high energy protons. (See "Dose equivalent").

Restricted area (controlled area): Any area access to which is controlled by the licensee or registrant for purposes of protection of individuals from exposure to radiation and radioactive material.

Roentgen: The special unit of exposure. One roentgen ® equals 2.58 X10-4 coulombs/kg or air. (See "Exposure).

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 which are likely to be encountered in normal use and handling.

Sievert (SV): An S.I. unit of dose equivalent which is equal to 100 rem.

EMERGENCY PROCEDURES

Campus Police	(713) 348-6000
Radiation Safety Officer Chris Mize	(713) 348-4444 (832) 370-6990
Environmental Health and Safety Department (Kathryn Cavender, Director)	(713) 348-4444
For emergency assistance and reporting Texas Department of Health 24 hour Radiological Emergency Assistance	(512) 458-7460

FIRE or EXPLOSION in RADIATION AREA

If small, and if you know how, attempt to extinguish the fire with the proper fire extinguisher.

1. If not, remove all personnel from the immediate danger area, shut doors (do not lock)
2. Call Campus Police or pull fire alarm and call the Radiation Safety Officer if RAM is involved
3. If necessary, evacuate the building
4. If possible, shut off all non-essential oxygen, gas and electrical appliances in the area
5. Re-enter the building **only** after the all clear is signaled by the alarm system or a safety official

Radioactive Material Spills

Minor (no radiation hazard to personnel):

1. Confine the spill immediately. Label the spill area.
2. Wear gloves. Absorb liquids with absorbent paper. Do not spread area. Damp wipe with proper solvent (usually water unless reactive with it).
3. Notify the Radiation Safety Officer.
4. Decontaminate
5. Survey

Major:

1. If spill is not volatile, wear gloves, right the container; evacuate personnel from the room, restrict access.
2. If spill is on clothing discard; decontaminate the individual.
3. Notify the radiation safety officer, stand by to assist.
4. Decontaminate the area per instructions from the Radiation Safety Officer; if volatile use appropriate full face protective breathing mask.
5. Monitor all persons and area to assess decontamination.
6. Prepare a complete report of the accident.

Medical Emergency

Minor: Fill out Rice's First Report of Injury Form, go to Hermann Hospital ER, (713) 704-4060.
Major: Call campus police for EMS; go to Hermann Hospital Emergency Room, 6411 Fannin, (713) 704-4060, tell medical personnel patient is on FAST TRACK; notify Dr. Lamki, Chief Radiologist/Nuclear Medicine (713) 704-1788 or Dr. Bing Sang, Radiation Safety Officer, (713) 704-2747, that a Rice employee is going to ER; when possible fill out First Report of Injury Form.

Appendix A: Address and Telephone Numbers

A. Rice University Personnel

1. Radiation Safety Officer
   Christopher Mize
   (713) 348-4444 - Office
   (832) 370-6990 - Mobile

2. Rice University Environmental Health and Safety Department:
   Kathryn Cavender, Director, (713) 348-4444

3. Rice University Police Department, (713) 348-6000, On campus: Ext. 6000

B. Waste Disposal Companies

NSSI/Sources & Services, Inc.,
P.O. Box 34042,
Houston, Texas 77234
Phone: (713) 641-0391

Monitoring and Survey Instrument Services

1. Microtec Services, Inc., 110 Charles Street, Pasadena, TX 77506, (713) 475-2274.

2. Monitoring Services, P.O. Box 580648, Houston, TX 77258-0648, (713) 641-0391.

3. Beckman Coulter; Corporate Headquarters: P.O. Box 3100, Fullerton, CA 92634,
   Phone: (800) 742-2345.

4. Suntrac, 1818 E. Main, League City, TX 77573; (281) 338-2133.

5. Temetrics, Inc., 9675 W. 76th Street, Eden Prairie, MN 55344, Phone: (952) 278-4437.

6. Atomic Energy Industrial Lab, 9315 Kirby Dr, Houston, TX 77054, Phone: (713) 790-9719.

Appendix B: Radioactive Material Request of Purchase

For permission to order and use of radioactive material, fill out the following portions of this form with a copy of the pre-experiment plan and send it to the Radiation Safety Officer for approval.

Note: All radioactive packages must first be shipped directly to the Radiation Safety Office so that Radiation Safety can check for contamination.

Use the following shipping address for all radioactive packages:

Environmental Safety
6500 Main Street
Houston, TX 77030
Attn: (Primary Investigator)
713-348-8801

Requestor _____ Email _____

Authorized User Name (PI) _____

Radionuclide _____

Compound name _____

Amount (mCi) _____

Additional Comments

Contact Person _____ Date _____

Department _____

Telephone Number _____

Appendix C: Pre-Experiment Plan for Use of Radioactive Material

Name of applicant: _____ Date: _____

Tentative duration of experiment: _____

List of radionuclide(s) to be used: (Students are limited to 100 □Ci C-14 or 500 □Ci H-3 per experiment)

Radionuclide	Amount mCi	Specific activity	Form

Have you had safety training of these radionuclides? _____

If no, arrangement must be made with your supervisor to receive training before use.

Brief Description of Experiment:

Include location and amount of radionuclide to be used in the specified area at any one time, location of storage of stock, general experimental methods, special precautions if radionuclides are volatile or reactive. Note method of containment of radioactive material to protect personnel and comply with license, form and methods of disposal of radioactive products and waste, for brevity, the researcher can make reference to the radiation license sections.

Signature of Supervising Licensed User:

Experiment Approved: _____ Date _____

Experiment Denied _____ Date _____

Explanation:

Appendix D: Unsealed Source Wipe Test Report

Building: _____ **Room Number:** _____

Principal Investigator: _____

Radioisotopes used in this Laboratory: _____

Counting Equipment ……. **Serial Number:** _____

Type: LSC or Other (specify):_____ **Model Number:** _____

Laboratory Diagram

Note: Attach all original data printouts from applicable survey and counting equipment.

Comments:

Wipe Test Samples

Number:	Location:	Result (CPM):
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.	_____	_____
26.	_____	_____

Surveyed By: _____

Date: _____

Appendix E: Semi-Annual Unsealed Source Inventory Report

Reporting Period:_____

Authorized User:_____

Note: All accidents and loss of radiation material must be reported to the RSO immediately. File this form and provide copy to the RSO on January and July of each year.

Holdings: Please estimate the amount of radioactivity you currently possess. This includes material held for decay or later disposal as well as receipts.

Receipts: Please report the radioactive material shipments you have received this period.

Isotope	Initial Volume	Initial Activity (mCi)	Date

Supplier	Chemical/physical form	Description

RADIOISOTOPE RUNNING LOG

Isotope	Activity Used (mci)	Amount Used	Amount (mCi) / Volume Remaining

Appendix F: Rice University Radioactive Contamination Survey Record

Principal Investigator: _____ Building/Room #:_____

Radionuclides used: _____

Survey Instrument

	Make, Model, Serial No.	Background (cpm)	Response Check or Calibration Date
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____

Contamination Survey Results

1. Enter work area, name of person surveyed, or location designation (number) per attached map.
2. Check "yes" if contamination found to be greater than two times background. If "yes", be sure to document that results after decontamination are less than two times background. Check "see attached" if results are contained on an attached printout. Call EHS at X4444 if assistance is needed.

Survey Date	Instrument Used	Location, Work Area, Object or Name of Person Surveyed	Contaminated? Yes / No / See Att.	Surveyed By
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____
_____	_____	_____	___/___/___	_____

Appendix G: Waste Disposal Report Form

Isotope:_____ Principal Investigator:_____ Inventory #:_____

Entry No.	Date	Starting amount (in mCi)							
		Disposal Form (in mCi)						Amount Disposed (mCi)	Remaining Inventory (mCi)
		Solid	Liquid	Vials	Primary Vial	Sharps	Other:		
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
Totals:									

Chemical Composition for **bulk liquid** waste and/or **vial** waste listed above	
Chemical Constituents	Concentration (with units)

_____ _____ _____

Principal Investigator (or designated) signature Printed Name Date

Waste Pickup by EHS:

Date:_____ By:_____

Appendix H: Radioactive Material Check-In and Delivery

ADMINISTRATIVE

Receipt Date: _____ PI: _____

Radionuclide: _____ Department: _____

Compound: _____ Delivery Location: _____

Activity Received: _____ Inventory Number: _____

MONITORING

EXPOSURE

10. Instrument(s): Type_____ Make/Model _____Serial Number_____

11. Package at 1 meter: _____ mR/hr

12. Package at surface: _____mR/hr

CONTAMINATION

13. Instrument(s) used: Type _____ Make/Model _____ Serial Number _____

14. Surface of package: _____ dpm/300cm^2

15. Primary Container: _____dpm/wipe

Package Comments:

Received By:

_____ _____

SURVEYOR PRINT NAME

_____

SIGNATURE

Appendix I: Rice University Environmental Health and Safety

Laboratory-Specific Radiological Safety Training Attendance Record

Last Name_____ First Name_____ Middle initial____

Department_____ P.I. _____

This training must be completed prior to the start of work with ionizing radiation. Both the principal investigator (or alternate) and the trainee are confident that the trainee is qualified to use (List all isotopes and radiation producing machines that were included in the training):

_____

_____

The following topics should be covered during the training. Check all that were covered.

[ ] Location of all permit paperwork, including access in the absence of the permit holder.
[ ] Permit review including approved nuclides, limits, laboratories, users, and any other restrictions.
[ ] Locations of required signs, notices, and EHS Radiation Safety Manual.
[ ] Where radioactive material is used within the lab(s) and restrictions on that use.
[ ] Storage location(s) and procedures for radioactive material security and storage.
[ ] Radioactive material waste segregation and disposal forms and inventory forms properly signed and dated.
[ ] Review of written protocols involving radioactive material.
[ ] Radiological safety considerations and potential for the generation of airborne radioactive material.
[ ] Special handling techniques which will minimize exposure when handling radionuclides.
[ ] Instruct trainee on the proper use of survey equipment and techniques.
[ ] Frequency for both routine and post operational surveys as applicable to your laboratory.
[ ] Availability of appropriate personal protective equipment and a discussion of its importance.
[ ] Emergency procedures including contact numbers, spill response instructions, and locations of eyewash stations, safety showers, and spill kits.
[ ] Review all shielding that is in place and the appropriate shielding type for your source.

_____ _____

Signature of P.I. or Alternate Date Signature of Trainee Date

Note: Radiological Safety training shall also be provided to persons who frequent areas where radioactive material is stored, but who do not work directly with the material. Such training shall include:

1. A brief discussion of the hazards of radiation and radioactive materials that are present.
2. Recognition of warning signs.
3. Area from which such persons are restricted.
4. Persons to contact in the event of an emergency.

Appendix J: EHS Waste Management Procedures

General Guidelines

- All radioactivity labels must be defaced or removed from containers and packages before disposal in ordinary (nonradioactive) waste. If waste is compacted, all labels that are visible in the compacted mass must be defaced or removed.
- Remind workers that nonradioactive waste such as leftover reagents, boxes, and packaging material should not be mixed with radioactive waste.
- Occasionally monitor all procedures to ensure that radioactive waste is not created unnecessarily. Review all new procedures to ensure that waste is handled in a manner consistent with established procedures.
- in all cases, consider the entire effect of various available disposal routes. Consider occupational and public exposure to radiation, other hazards associated with the material and routes of disposal (e.g., toxicity, carcinogenicity, pathogenicity, flammability), and costs.
- The waste management program should include waste handling procedures for the users within their laboratories or assigned areas, and for waste handlers that may collect waste from areas of use to bring to the storage area for eventual disposal.
- Housekeeping staff should be provided adequate training to avoid the possibility of unauthorized disposal or exposure of these individuals to radioactive materials or to radiation.
- A waste generator, collector, or processor who transports, or offers for transportation, low-level radioactive waste intended for ultimate disposal at a licensed low-level radioactive waste land disposal facility must prepare a Manifest in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 10 CFR Part 20, Appendix G, “Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests.”

Model Procedure for Disposal by Decay-in-Storage

Applicants should ensure that adequate space and facilities are available for the storage of waste for decay-in-storage (DIS). Licensees can minimize the need for storage space if the waste is segregated according to physical half-life.

- Only short-lived waste (physical half-life of less than or equal to 120 days) may be disposed of by DIS.
- Short-lived waste should be segregated from long-lived waste (half-life greater than 120 days) at the source.
- Waste should be stored in suitable well-marked containers, and the containers should provide adequate shielding.
- Liquid and solid wastes should be stored separately.
- When the container is full, it should be sealed. The sealed container should be identified with a label affixed or attached to it.
- The identification label should include the date when the container was sealed, the radionuclide(s)

in the container and estimated amounts, and the initials of the individual who sealed the container. The container may be transferred to the DIS area. When large quantities are held for DIS, sufficient quantities may be present even after many half-lives that persons performing surveys should be aware of the potential for measurable radiation.

- The contents of the container should be allowed to decay for a period of time after which it is expected that the radiation levels would not be distinguishable from background. The period of time depends on both the half-life of the radionuclide(s) and the original amount present.
- Before disposal as ordinary trash, each container should be monitored with an appropriate radiation detection instrument, on the lowest setting, as follows:
    - Check the radiation detection survey meter for proper operation.
    - Survey the contents of each container in a low background area.
    - Remove any shielding from around the container.
    - Monitor all surfaces of the container.
    - Discard the contents as ordinary trash only if the surveys of the contents indicate no residual radioactivity (i.e., surface readings are indistinguishable from background).
    - If the surveys indicate residual radioactivity, return the container to DIS area and contact the radiation safety officer for further instructions.
    - lf the surveys indicate no residual radioactivity, record the date when the container was sealed, the disposal date, type of waste (e.g., used or unused material, gloves, etc.), survey instrument used, and the initials of the individual performing surveys and disposing of the waste.

In accordance with 10 CFR 20.1904(b), all radiation labels must be defaced or removed from containers and packages before disposal as ordinary trash. Syringes and needles placed into sealed waste containers for decay do not need to have the labels removed, provided that the following is done: waste barrels are sealed before delivery to the waste disposal firm and delivered directly from the licensee's facility; labels are removed from the waste barrels and containers; the waste is incinerated, not placed in a landfill; and the waste disposal firm is cautioned not to open the container before incineration.

Model Procedure for Disposal of Liquids into Sanitary Sewerage

- Confirm that the sewerage system is a public system, not a private sewerage system, septic system, or leach field.
- Confirm that the liquid waste being discharged is either soluble material, or a biological material that is readily dispersible in water.
- Calculate the amount of each radionuclide that can be discharged by using the information from previous, similar discharges and the information in 10 CFR Part 20, Appendix B.
- Make sure that the amount of each radionuclide does not exceed the monthly and annual discharge limits specified in 10 CFR 20.2003(a)(4) and in 10 CFR Part 20, Appendix B, Table 3 (records for individual users/laboratories).
- If more than one radionuclide is released, the sum of the ratios of the average monthly discharge of a radionuclide to the corresponding limit in 10 CFR Part 20, Appendix B, Table 3 must not exceed

unity.

- Confirm that the total quantity of licensed material released into the sanitary sewerage system in a year does not exceed 185 gigabecquerels (GBq) [5 curies (Ci)] of H-3 (tritium), 37 GBq [1 Ci] of C-14, and 37 GBq [1 Ci] of all other radionuclides combined.
- Record the date, radionuclide(s), estimated activity of each radionuclide, location where the material is discharged, and the initials of the individual discharging the waste.
- Liquid waste should be discharged only through designated sinks or toilets, or release points.
- Discharge liquid waste slowly to minimize splashing, with water running to be sure that the material moves out of the sink and into the sewer system.
- Survey the sink and surrounding work surfaces to confirm that no residual material or contamination remained in the sink or on work surfaces.
- Decontaminate all areas or surfaces, if found to be contaminated.
- Maintain records of releases of licensed material to the sanitary sewer system. These records should include, for each release, the date, radionuclide(s), estimated activity of each radionuclide, location where the material is discharged, and the name of the individual discharging the waste. For the licensed facility as a whole, records should be maintained of the quantity and concentration of radionuclides that are released into the sewer system that demonstrate compliance with the regulatory limits for total quantity released and concentrations released by the licensed facility.

Model Procedure for Incineration

These guidelines apply to noncommercial waste disposal (i.e., incineration of a licensee's own waste). Specific U.S. Nuclear Regulatory Commission (NRC) approval to incinerate certain categories of radioactive waste is not needed. For example, 10 CFR 20.2005 provides that tritium and carbon-14 in low level concentrations in liquid scintillation media and animal tissue may be disposed of without regard to radioactivity.