RADIATION SAFETY MANUAL

Dr. Chellu S. Chetty
Radiation Safety Officer
Savannah State University
Savannah, GA-31404

(Revised on January 30, 2012)

Table of Contents

Statement of Radiation Protection Policy:

In order to assure the safe use and control of radioactive materials, it is the policy of Savannah State University (SSU) to:

1. Exercise control over operations involving the use of radioactive materials,
2. Assure that exposure of personnel to ionizing radiation from radioactive materials is kept as low as reasonably achievable,
3. Assure compliance with applicable federal, state, and local regulations, and
4. Assure that each supervisor and principal investigator carries out their responsibilities for training employees, technicians, or assistants in the safe and proper use of radioactive materials.

I. Organization and Responsibilities:

Savannah State University (SSU) is authorized to use radioactive materials under Georgia Radioactive Materials License issued by the Georgia Department of Natural Resources and Regulations (GDNRR), Chapter 391-3-17. Continuing license authority is contingent upon the establishment and maintenance of a radiation safety program that will insure that licensed radioactive materials are used in an acceptable manner and in accordance with federal and state regulations and institutional policies. The procedures contained in the Radiation Safety manual outline radiation safety practices applicable to personnel working with radioactive materials under the authority of the Savannah State University's GDNRR license. The manual outlines procedures established by the SSU's Radiation Safety Officer to assist authorized investigators to fulfill their responsibilities for radiation safety. The responsibility for using radioactive material in a safe and acceptable manner ultimately rests with the authorized investigator. It is essential that all personnel working with radioactive material be familiar with the contents of the radiation safety manual and conducts his/her activities in accordance with the procedures contained therein.

The purpose of the Radiation Safety Program is to ensure that work with radioactive materials conducted in such a manner as to protect health, minimize danger to life and property and keep radiation exposure ALARA (As Low As Reasonably Achievable). Responsibility for enforcement of this policy is vested in the Radiation Protection Officer (RPO) and should be consistent with the goals of the University.

The Radiation Safety Manual is a formal statement of policy, operating procedures and standards of conduct for Savannah State University set forth by the Office of Sponsored Research Administration, and the Radiation Safety Officer. The purpose of the manual is to establish policy and provide guidance for individuals using or have responsibility for the use of radioactive material to comply with university policy, university license conditions, the Code of Federal Regulations 10 CFR 20, and the GDNRR, Chapter 391-3-17. Each Principal Investigator

(PI) who is authorized to use radioactive material is issued a Radiation Safety Manual and is responsible for complying with its policies. The PI must keep a current copy of the Radiation Safety Manual in the laboratory.

II. Radiation Safety Officer: The Radiation Safety Officer (RSO) is responsible for maintaining the Radiation Safety Program and administering the policies set forth by the University. The RPO is responsible for assuring that use of ionizing radiation meets all applicable government regulations and is responsible for the safety of the students, faculty and general public regarding radiation exposure. The RPO has the authority to immediately terminate any procedure involving radioactive material or radiation producing machines, which is judged to be a hazard to health and safety of the worker and general public.

- Provide liaison in negotiations for licensing between the GDNRR and SSU
- Implement the policies and procedures developed by the SSU
- Coordinate the safety evaluations of all proposed user applications and uses of radioactive material to ensure compatibility with appropriate materials license conditions, rules and regulations
- Develop and maintain uniform methods, standards and procedures and the quality thereof for radiation safety coverage at SSU
- Provide information on all aspects of radiation safety to personnel at all levels of responsibility in accordance with the ALARA philosophy
- Write and publish general guidelines or procedures for radiation safety
- Perform quarterly audits of authorized users laboratories, facilities, and experimental protocols and personnel training
- Receive, inspect and deliver all incoming shipments of radioactive materials and receive, package, label and ship all outgoing shipments of radioactive materials
- Maintain a quarterly inventory of all radioactive materials including those in storage and as waste
- Supervise and coordinate the radioactive waste disposal program including records pertaining thereto and maintain storage facilities
- Supervise the personnel monitoring program including determining the need for and evaluation of bioassays, maintain exposure records, notify personnel of exposures and provide recommendations for any remedial actions necessary to reduce personnel exposure
- Maintain all records pertaining to the radiation safety program
- Perform leak tests of all sealed sources
- Supervise decontamination and recovery operations in case of contaminating accidents

Authorized User: Savannah State University has Georgia Radioactive Materials License issued in accordance with the general requirements contained in the Georgia Department of Natural Resources Rules and Regulations, Chapter 391-3-17. The license contains the specific terms and conditions of radioactive material use at SSU, including types, forms, quantities, uses, locations and specific procedures that will be followed.

Any person who wishes to use ionizing radiation on the University Campus must submit an application to the RSO. The application may be approved; provided that the potential user furnishes evidence that the individual has training, experience and equipment necessary to safely handle the radioactive material. The RSO will provide the user with an operating procedure, which addresses safety and the needs of the user.

A. Principal Investigator: The Principal Investigator is personally responsible for compliance with University and governmental regulations as they pertain to their authorized use of radioactive material or radiation producing machines. The PI's specific responsibilities include, but are not limited to:

1. Adhering to all requirements contained within the Radiation Safety Manual and the Radiation Use Authorization (RUA).
2. Maintaining proper records as required by the Radiation Safety Officer, such as; radioisotope inventory, surveys and material transfers.
3. Posting any required signs and labels on radioisotope containers, storage locations and use areas.
4. Assuring that radioactive waste is disposed of properly as detailed in the Radiation Safety Manual.
5. Notifying Radiation Safety Officer promptly of changes in locations and procedures,
6. Notifying Radiation Safety Officer immediately in cases of personnel contamination, excessive contamination (spills), suspect occupational radiation exposure, accidents or unusual event, and
7. Ensuring personnel receive the necessary training.

B. Individual Users: Each user of radioactive materials has a responsibility to:

1) Know potential exposure prior to starting work and survey work area before and after procedure using the appropriate instrument.
2) Not to smoke, eat or drink or store consumables (including beverages) in radioisotope laboratories.
3) Wear gloves and laboratory coats during procedures.
4) Wear shoes i.e., no slippers or sandals.
5) Use absorbent paper on trays and bench tops.
6) Use hoods for aerosols, vapors and dusts.
7) Not relocate radioactive materials outside of posted areas (except to count samples)

8) Wash hands, face before leaving and monitor work location with meter.
9) Seal stock containers and put away after use.
10) Label all radioactive materials and containers.
11) Notify RSO if pregnant.
12) Contact PI or RSO if you have any questions regarding radiation safety or radiological concern.
13) Report all spills to PI and RSO.

III. Laboratory Procedures:

A. Purchase of Radioactive Material: To obtain radionuclides, under GDNRR Radioactive Material license for use at SSU only, obtain a license application form from the Radiation Safety Officer. The Radiation Safety Officer (RSO) will do all purchasing of radioactive materials.

Receipt and Delivery of Radioactive Materials: When a shipment of radioactive materials is received at the SSU, the Receiving Department will immediately notify the Radiation Safety Officer. The package will be picked up at the Receiving Department by RSO who will inspect the package in accordance with GDNRR 391-3-17-.03(11)(f). The package is then delivered to the investigator. The investigator is responsible for inspecting and opening certain packages, i.e., dry ice shipments and RIA kits, which are not opened by the Radiation Safety Officer.

B. Storage of Radioactive Material: Store radioisotopes in such a manner as to prevent unauthorized use or removal. Storage must be in a secure area or under lock and key when the laboratory is vacant for any reason. Radioactive materials must not be stored in refrigerators used for food or in any containers in the hallways.

C. Use of Radioactive Material: Prior to work with radioactive materials, the investigators will be approved by the Radiation Safety Officer. They are responsible for supervising the work being done under their authorizations.

D. Training of Personnel: The minimum training requirements for each individual entering a restricted area where radioactive materials are present are described in 10 CFR 19.12. The authorized principal investigator is responsible for training the individuals working in their laboratory. The Radiation Safety Officer assists the principal investigator by providing lectures on radiation safety. Investigators are responsible for insuring that new individuals receive appropriate radiation safety training before they begin working with radioactive material in the laboratory. Training should include:

1. principles of radiation safety
2. use of monitoring instruments
3. protective equipment to be used
4. how to contact a Radiation Safety Officer

5. reading of the Radiation Safety Manual--A copy of the manual must be available at all times to laboratory personnel.
6. proper packaging of waste
7. decontamination procedures
8. proper record keeping

E. Protective Equipment

i) Luxel Radiation Dosimetry Badges: The Radiation Safety Officer will provide the Luxel badges to the personnel monitoring services to assess radiation exposures, when appropriate. Except for individuals using soft beta emitters or other radiation sources as determined by the RSO, everyone directly involved with radioactive material will be required to have and wear a Luxel badge when working. The old Luxel badges are collected quarterly and sent off for processing (Landauer, Inc. 2 Science Road, Glenwwod, IL 60425-1586; phone: (708) 755-7000; Account # 309911). The Luxel badge users are provided a written report of their exposure on an annual basis. Copies of these reports are on file with the Radiation Safety Officer. The Radiation Safety Officer reviews all reports and individuals with excessive or unusual exposures are contacted. The Radiation Safety Officer gives the following instructions to the personnel using the Luxel badges:

- The Luxel badge should always be worn
- Do not store the Luxel in a radiation area or in areas with excessive heat or moisture. Do not take the badge home.
- Return the Luxel badges to the Radiation Safety Office if monitoring is no longer needed or employment at SSU has ended.

ii) A lab coat (or apron) and gloves, are a minimum requirement and must be worn when handling unsealed sources. Shoes with closed toes are required.

iii) Gamma samples producing more than 37.5 mrem/hr (3.75 x 10^{-4} Sieverts/hr) at contact should be handled with tongs. Hard betas, such as those from ^{32}P, should be handled with tongs if the quantity exceeds 1 millicurie.

iv) Protective clothing used in the radioisotope laboratory should not be worn outside the laboratory.

v) Fume hood specifications: The protection fume hood in DG Annex room 109 will be used for safe handling of 3-H, 35-S, 125-I, 14-C and other volatile radioisotopes. This fume hood (Kewaunee Scientific Equipment Corp.) has stainless steel lining and with minimum air handling capacity. One millicurie of non-volatile material may be approved for a laboratory without a fume hood.

F. Radiation Protection Procedures:

1. *Shielding:* Appropriate shielding should be provided so that the dose equivalent measured at 30 cm from sources (i.e. stock solutions etc.) will not exceed 2 mrem in any hour.
2. *Radioactive Gases, Dusts, and Aerosols:* Procedures involving aerosols, dusts or gaseous products, or procedures, which might produce airborne contamination, shall be conducted in an approved hood.
3. *Individual Users:* The purpose of this section is to provide procedures by which laboratory personnel may maintain a safe working environment and avoid contamination of equipment and facilities.

- Never perform extensive radiochemical work with hazardous levels of material until the procedure has been tested by a dry run to preclude unexpected complications.
- Keep work areas clean and organized to minimize accidents, contamination and exposure.
- Secure laboratory and storage areas against tampering, loss, theft, or unauthorized removal of radioactive and contaminated material. If radioactive materials are present within the laboratory, then the entrance door(s) must be closed and locked, unless other arrangements have been permitted, when the laboratory is unattended.
- Wear prescribed monitoring equipment such as Luxel badge.
- Do not smoke, eat, drink or apply cosmetics in areas of your laboratory where radioactive materials are used and/or stored. Refrigerators/Freezers used for storage of radioactive materials shall not be used for storage of food or beverages.
- Use appropriate protective measures such as:
    1. Wear a laboratory coat or other protective clothing when working with radioactive material or while in areas where they are used. Do not wear possibly contaminated clothing outside the laboratory.
    2. Wear disposable gloves at all times while handling radioactive materials. Change gloves as necessary to prevent spread of contamination.
    3. Use protective barriers or shielding whenever possible. Lead barriers and lead-glass windows are appropriate for gamma emitters. Thick plexiglass shields are preferred for hard beta emitters.
    4. Use remote handling devices such as forceps and tongs for handling high activity samples of gamma or hard beta emitters.
    5. Use pipette-filling devices. **NEVER PIPETTE RADIOACTIVE SOLUTIONS BY MOUTH**.
- When possible, use spill trays for performing all operations involving radioactive materials. Do not use cafeteria trays. In case of a spill, the tray limits the spread of

contamination and simplifies clean up. Cover bench top work areas with easily decontaminated or removable materials such as absorbent pads with waterproof backing.

- Keep "high activity" vials and syringes in shielded containers.
- Confine radioactive solutions in covered containers that are clearly identified and labeled with the name of the radionuclide, chemical compound, date, activity, and radiation exposure rate, if applicable.
- Label and isolate radioactive material, waste, glassware and contaminated equipment. Glassware and equipment should not be released for other use, or removed for cleaning, repair, or as surplus property, until demonstrated to be free of contamination.
- Always transport radioactive material in shielded containers.
- Immediately report accidental inhalation, ingestion or injury from radioactive materials or other source of radiation to the Authorized Investigator and the Radiation Safety Officer.
- Ideally a survey of the immediate and adjacent work areas should be done at least once each day when radioactive materials are used. A record of all surveys, including negative results, should be maintained in the Radiation Safety notebook. Records of monthly surveys are required.
- Survey hands, body and protective clothing, and remove any contamination before leaving the work area to eat, drinks, smokes or work in another area.
- Decontamination should be performed in a manner that prevents the spread of contamination to other areas.
- Comply with Radiation Safety Office requests to evaluate internal/external exposures to radiation through bioassay samples and procedures.

IV. Personnel Exposure

The occupational radiation exposure limits at SSU are based upon those specified in Title 10, Part 20 of the U.S. Code of Federal Regulations (10 CFR 20) and the Georgia Department of Natural Resources and Regulations (GDNRR), Chapter 391-3-17.These limits have been established as maximum values, and, in all cases, personnel exposure must be maintained as far below these limits as possible. A particular effort shall be made to keep the radiation exposure of the embryo/fetus to the lowest practicable level during the entire period of the pregnancy as recommended by the National Council on Radiation Protection and Measurements and as required by the GDNRR. Occupational Dose Limits in Controlled Areas Personnel shall not be occupationally exposed to ionizing radiation such that the following limits are exceeded:

1. a. Total Effective Dose Equivalent (TEDE)..................5000 mrem/year [50 mSv/yr] This is the deep dose from external sources of radiation plus the calculated internal dose over a 50-year period to all organs of the body from internalized sources of radiation*. - OR -

b. Total Organ Dose Equivalent (TODE)..................50,000 mrem/year [500 mSv/yr] This is the deep dose from external sources of radiation plus the calculated dose over a 50-year period to any organ or tissue (except the lens of the eye) from internalized sources of radiation*.

* The internal dose, if any, will be determined from bioassay results, monitoring for airborne radioactivity, or some other method, and reported with the complete exposure history.

2. Lens of the Eye ....15,000 mrem/year [150 mSv/yr]

3. Dose to the Skin and/or Extremities*................50,000 mrem/year [500 mSv/yr]

*"Extremity" refers to the hand, elbow, arm below the elbow, foot, knee, and leg below the knee.

Radiation Dose Limits for Minors**:** The annual dose limit to minors (under age 18) from external and internal radiation sources is set at 10% of the adult occupational limits, as stated above.

Radiation Dose Limits to Pregnant Women (for the Embryo/Fetus): The radiation dose to pregnant personnel working in restricted areas shall be limited to less than 0.5 rem (5 mSv) during the entire period of pregnancy (about 55 mrem/month average). Supervisors shall instruct female personnel of child-bearing potential that it is in their best interest to make a formal, written declaration of pregnancy as soon as possible after they become pregnant.

Radiation Dose Limits in Unrestricted Areas: Radiation dose limits in unrestricted (uncontrolled) areas shall be such that an individual will not receive a dose to the whole body in excess of 0.1 rem/year.

V. Radiation Warning Signs and Labels

All Authorized Investigators must comply with the following procedures and must ensure that individual users under their direction adhere to these rules.

A. Identification of Use Areas and Equipment:

1. A Caution Radioactive Material sign must be conspicuously posted on each door to laboratory areas where radioactive materials are used or stored. The names(s) and phone number(s) of personnel to be contacted in case of an emergency should also be posted.
2. Storage areas shall be conspicuously marked with a Caution Radioactive Material sign. All containers in which materials are stored or transported must be similarly identified. These signs should state the radionuclide, activity and the date.
3. Any accessible area where an individual could receive a dose equivalent in excess of 5 mrem in one hour at 30 cm from the radiation source shall be posted with a Caution Radiation Area sign.
4. Equipment contaminated with radioactive material shall be appropriately labeled.
5. Sinks used for washing of RAM contaminated items, such as glassware, and/or disposal of low level radioactive liquid waste must be labeled with "Caution Radioactive Materials" tape. A disposal log sheet must also be conspicuously posted.

VI. Waste Management

A) Radioactive Waste Handling and Disposal Procedure: By definition, **"radioactive waste"** is "solid, liquid and gaseous materials which spontaneously emit ionizing radiation OR which are suspected or known to be radioactively contaminated in excess of the acceptable limits, AND for which there are no further uses". Radioactive waste items typically include: Sample tubes, pipette tips, gloves, bench paper, paper towels/kimwipes, Scintillation vials and Cocktail, Liquids and Gels, Sharps (broken glass, needles, razor blades, etc.) etc.

In the interest of environmental protection and cost reduction, every individual worker should make reasonable efforts to minimize the amount of radioactive waste that is generated. Methods by which this can be accomplished include:

1. Preplan and organize work. Use the minimum amount of materials necessary to carry out each procedure.
2. Utilize good radiological work practices to minimize the spread of radioactive contamination. This will result in fewer decontamination procedures, which will, in turn, generate less waste. All decontamination operations create some waste.
3. Carefully consider decontamination methods in terms of waste reduction. Use the minimum amount of materials possible, and always begin with the simplest methods before proceeding to more complex, waste- generating methods.
4. Do not cross-contaminate wastes by mixing radioactive items with nonradioactive items.
5. Consider possible alternatives to decontamination, such as disposal of the contaminated item itself as radioactive waste, or storing the item until the radioactivity has decayed. There are several different categories of radioactive waste; each with its own unique handling and disposal requirements. In general, radioactive waste materials are segregated according to physical form, radioisotope, and chemical content. The procedures for handling each type of waste are outlined in the following pages of this handbook. The disposal of radioactive waste is closely regulated by local, state and federal agencies; therefore compliance with approved waste procedures is essential.

B) Waste Handling Guidelines and Requirements:

Radioactive Waste Containers **--** Personnel are only to use the types of containers specified by RSO for radioactive waste collection.

Labeling: All containers used for the collection of radioactive waste shall be conspicuously labeled as "radioactive material". Such containers include: covered "step" trash cans, plexiglass boxes, bulk liquid containers, "sharps" boxes, etc. Additionally, the radioisotope(s) of concern and the amount of radioactivity (Ci or mCi) should be clearly indicated on each container. All material designated as radioactive waste must be identified with a Radioactive Waste Tag. "Identification" requires stating the following minimum information on the waste tag:

* the isotope(s)
* the amount of radioactivity (Ci/mci)
* principal investigator's name
* laboratory room number
* date placed in waste

Yellow Bags: Containers used for the collection of solid radioactive waste should be lined with yellow plastic radioactive material bags.

The biodegradable liquid scintillation fluid containing short lived (T1/2<90 days) isotopes will be held for decay in room 111 prior to disposal if the half-life is less than 90 days. The vials with non-biodegradable liquid scintillation fluid containing long half-lived isotopes (T1/2>90 days) will be stored in a 30 gallon drum supplied by the waste pick up company (Bionomics, Kingston, TN). No radioactive materials may be disposed by sewer without specific approval from RSO. In case such disposal is approved, records must be maintained listing isotope, amount, and date of disposal. Mixed waste is waste, which contains hazardous chemicals in addition to radioactive material. Both the chemical and the radiation hazard must be considered in the disposal of this waste. Sometimes the radioactive material can be held for decay and the chemical then disposed of as a hazardous chemical.

Sharp Objects: Hypodermics, broken glass, and other sharp objects must be packaged to avoid injury to persons who must handle the waste. Place such objects in a plastic jar or metal container and secure with tape before placing them with the solid materials. (Label as sharp objects). Do not use "RADIOACTIVE MATERIALS" tape to secure the container before it is placed in the solid materials container.

Uncontaminated Materials: Do not place uncontaminated materials in the used radioactive materials container. Packing, boxes and other such materials, when not contaminated, should be placed in the non-radioactive waste can for disposal at the city landfill.

VII. Radiation Surveys

To ensure radiation doses, both internal and external, are **as low as reasonably achievable (ALARA)**, radiation monitoring must be conducted by lab personnel. Radiation monitoring is used to detect the presence of radioactive contamination from open source work, detect the presence of radioactive leakage from sealed sources, and detect the presence of exposure fields from radioactive materials.

A. Laboratory Surveys: The immediate areas (e.g. hoods, bench top etc.) in which radioactive materials are being used should be checked for contamination at least monthly or as otherwise directed by the Radiation Safety Officer. Surveys generally consist of an evaluation with swipe media for removable contamination and may include a survey meter with a GM or NaI detector probe for fixed/removable contamination.

1. Authorized Investigators are required to document each radiation survey for their laboratory at least monthly if radioactive materials are in use. Alternative survey requirements must have prior approval of the Radiation Safety Officer.
2. A quarterly survey of laboratories will be conducted by the Radiation Safety Officer. *The quarterly surveys will consist of:*
   a. A measurement of radiation levels with a survey meter sufficiently sensitive to detect 0.1 mR/hr.
   b. A series of wipe tests to measure contamination levels.
3. A permanent record will be kept of all survey results, including negative results, and results of decontamination efforts.

B. Survey Procedures and Methods:

<u>*Ambient Radiation Level Surveys:*</u> These types of surveys are conducted within your work areas and are used to determine the ambient radiation levels caused by radioactive materials used or stored in your areas. Such types of measurements can only be taken with an ion chamber or a properly calibrated survey meter equipped with a GM detector probe.

<u>*Contamination Level Surveys:*</u> The only true survey for loose (removable) surface contamination is the wipe test survey method. However, prior to taking wipe samples, an initial check for contamination can be performed using a survey meter to directly monitor surfaces of interest. Use a survey meter with an appropriate detector probe to survey bench tops and other work areas. A survey instrument can be used to perform a relatively quick check of the work area to draw attention to areas requiring possible decontamination. If any areas were found which exceed twice the background radiation levels, then decontamination procedures would be worthwhile at this point prior to taking wipe samples. Using filter paper discs or cotton swabs, take a series of wipes from working surfaces where contamination could be expected to exist or where radiation levels are elevated. Each wipe should be numbered and the location where they are taken shown on the sketch as described above for radiation surveys. The wipes should be rubbed firmly over a surface area of about 100 cm^2 in order to consistently determine the amount of removable surface contamination. The wipes shall be analyzed using a gamma or liquid scintillation counter, as appropriate. The amount of removable contamination shall be recorded in the units of disintegrations per minute (dpm)/100 cm^2.

<u>*Techniques for Using Portable Radiation Survey Instruments*</u>*:* When using portable radiation survey instruments, it is essential that the proper techniques be employed to assure accurate results. Failure to utilize the correct techniques usually will result in an inadequate survey.

1. The detector's "window" should be held as close as possible (within about 1 cm) to the surface being measured. Use extreme care to avoid actually touching surfaces and spreading

radioactive contamination to the detector. Remove plastic coverings, if present, from the detector window as this will effectively shield out lower energy radiations and preclude their detection.

2. Scan surfaces slowly enough to detect the presence of low levels of radioactive contamination. Typically, the rate of detector movement should not exceed about 1" to 2" per second.
3. ALWAYS use the instrument's audible response while conducting surveys. The audible response is much faster than the meter indication. While scanning areas, you should listen to the "clicks" of the instrument rather than relying on meter deflection. What you are listening for is any increase in the rate of "clicks" above normal background levels. When you note any increases, stop and scan that area more thoroughly. Any sustained increase above background levels should be investigated.
4. Ensure that you select the proper scale on the instrument for conducting the survey. Whenever scanning surfaces for radioactive contamination, ALWAYS use the lowest scale (i.e., x0.1 or x1 scale) available. Select higher range scales as necessary to obtain maximum readings if contamination or other measurable radiation is detected.

IMPORTANT: Remember that tritium (^3H) is such a low-energy beta emitter that it cannot be detected by direct scan with any survey meter. WIPE TESTS ONLY!!

Techniques for Conducting Wipe Test Surveys for Surface Contamination:

1. ALWAYS wear a clean pair of gloves and change them during the survey if you know or suspect that they have become contaminated. This ensures that you will not cross contaminate any wipe samples.
2. Use cotton swabs or filter paper discs as your wipe material. Dry wipes are normally used because they will more closely represent the spread of contamination that would occur due to personnel brushing against contaminated surfaces. It is acceptable to use wipes that have been slightly moistened, if desired.
3. To perform the survey, rub the wipe material firmly over a 100-cm2 area of the surface of interest. The 100-cm2-wipe area is widely used for loose surface contamination surveys. The reasons for using this wipe area are:
   - this area provides nearly an optimum efficiency for collecting and measuring loose surface contamination;
   - this is a convenient area to measure; and
   - wipe materials tend to disintegrate when wiped over larger areas.
4. ALWAYS assign a number to each wipe AND make a sketch or use some other type of record to indicate where each individual wipe sample was taken.

Procedures for Counting Wipe Samples:

1. Liquid Scintillation Counting (LSC) [USE FOR ANY RADIOISOTOPE]

a. Deposit wipe sample into a clean scintillation vial.

b. Fill the vial at least 2/3-full with scintillation cocktail.
c. Tightly cap the vial.
d. Mix the contents of the vial thoroughly ("vortex").
e. Count the sample for at least 1 minute in a liquid scintillation counter. **Always include a "Background" Vial** (an unused wipe prepared with cocktail).
f. Examine the counting results. Any wipe sample indicating radioactivity levels of 200dpm/100 cm^2 or more requires that the surface of concern be decontaminated. All affected surfaces must be CLEANED and REWIPED until all loose surface contamination has been removed (i.e., wipes indicate background readings).

2. Gamma Scintillation Counting [USE FOR GAMMA-EMITTING RADIOISOTOPES]

a. Deposit wipe sample in a clean scintillation vial. (DO NOT USE COCKTAIL)
b. Count the sample for at least 1 minute with a gamma scintillation counter. **Always include a "Background" Vial**.
c. Examine the counting results. Any wipe sample indicating radioactivity levels of 200-dpm/100 cm^2 or more requires that the surface of concern be decontaminated. All affected surfaces must be CLEANED and REWIPED until all loose surface contamination has been removed (i.e., wipes indicate background readings).

3. Important Notes Regarding Scintillation Counting

a. Scintillation counters should come equipped with a set of radioactive counting standards" which are to be analyzed by the counter periodically to check its operation. Ideally, the standards should be counted as often as the scintillation counter is used for counting samples, i.e., daily or weekly. Scintillation counters should be scheduled for routine and preventive maintenance by a qualified service technician to ensure that they will provide reliable counting results.
b. Whenever possible, select a liquid scintillation cocktail that is biodegradable and requires little special handling, storage, or disposal.
c. The control limit for removable surface contamination is expressed in the units of "dpm"(disintegrations per minute). This can pose some difficulty when interpreting the results of scintillation counting of wipe tests, due to the fact that most scintillation counters print out results as "cpm" (counts per minute). The "dpm" and the "cpm" are not equivalent units, and relating one to the other can be difficult because of the many variables associated with counting radioactive samples. Factors that affect the counting results of samples include: counting time, sample volume, sample distribution and geometry, background radiation, efficiency of the counter for measuring certain radiation energies. Thus, keeping all of this in mind, we can establish a general rule of thumb to be applied for the purposes of wipe test counting only, and that is that approximately 80 to 120 cpm above background as indicated by

a liquid scintillation counter can be considered to be contaminated at or near the control level (i.e., >200 dpm).

<u>*Survey Methods Required for Commonly-Used Radioisotopes:*</u> In order to assure that surveys for ionizing radiation and radioactive contamination are reliable, it is essential that personnel utilize the correct detector and survey method as determined by the radioisotope of concern. The following table delineates which type of detector and survey method are required for most of the frequently-used radioisotopes at Savannah State University.

METHOD 1: Liquid Scintillation Wipe Test

METHOD 2: Gamma Scintillation Wipe Test

Radioisotope	Survey Method(s) Required
^{3}H	#1
^{32}S ^{45}Ca ^{14}C	#1
^{32}P	#1
^{125}I	#1 or #2
^{51}Cr	#1 or #2

C. Contamination Limits: Work areas and equipment will be kept as free of contamination as is practical.

1. In restricted areas, levels of removable contamination should not exceed 1000 dpm per 100 cm^2 for beta and gamma emitters and 100 dpm per 100 cm^2 for alpha emitters. Fixed contamination should not exceed 0.5 mR/hr at 1 cm from the surface.
2. Unrestricted areas should not have removable contamination levels in excess of one-tenth of the limits stated for restricted areas. Fixed contamination should not result in an exposure rate in excess of 0.2 mR/hr at 1 cm from the surface.
3. Personnel must monitor skin and clothing regularly. Contaminated skin should be gently cleaned to as low as reasonably achievable. Contaminated clothing should not be worn until it has been decontaminated through cleaning or decay. The Radiation Safety Officer should be notified immediately of all such incidents.

D. Repair and Maintenance of Contaminated Equipment: Equipment in which radioactive material has been used shall not be released for other work or repair by either University as surplus property until certified to be free of contamination by the Radiation Safety Officer. If repair of contaminated equipment is necessary, the Radiation Safety Officer must be notified to assure that necessary precautions are observed.

E. Decontamination of Personnel:

1. If possible, obtain a quick meter survey of the contaminated area.
2. The immediate washing of contaminated areas with luke-warm water and a mild soap is the method of choice for two to three minutes at a time. Washing can be helped by scrubbing with a soft brush taking care not to abrade the skin. Dry the skin and monitor. Repeat

washing, if necessary, three or four times. Record monitor readings and note distances at which readings were taken.

3. Call the Radiation Safety Officer as soon as practical.
4. Use of organic solvents or of acid or alkaline solutions should be avoided.
5. Special attention should be paid to proper decontamination of creases, folds, hair and fingernails. Care should be taken to avoid spreading the contamination to uncontaminated parts of the body. Attempt to remove the contamination locally with absorbent material and, if necessary, with a proper masking of adjacent non-contaminated areas of the skin. Protect open non- contaminated wounds.
6. Special care should be taken not to contaminate the eyes or lips.
7. Decontamination of the eyes should be undertaken immediately. Irrigate the eyes with a copious amount of water or with appropriate medically approved solutions.

F. Decontamination of Areas and Equipment: Decontamination efforts should begin as soon as contamination is found. The extent, type and hazard of contamination should be evaluated and the limits of the affected area marked prior to starting the clean up. The Radiation Safety Officer will assist in this evaluation and will recommend appropriate decontamination methods.

G. Transport of Radioactive Materials: In transporting radioactive material from one area to another, special precautions must be taken to avoid accidental spills or release of radioactivity to the environment. Materials producing external radiation should be shielded to keep radiation levels as low as reasonably achievable.

1. For transport between rooms no special packaging is required. However, containers (i.e. tubes, flasks etc.) with radioactive material solutions must be capped and should be transported in a suitable outer container that would protect the material if dropped.
2. For transport between buildings, radioactive materials should be shielded and packed so that there will be no spill or release in the event the package is dropped. The inner container should be packed in sufficient absorbent material that would absorb any liquid released through breakage or leakage.

H. Laboratory Survey Equipment: Each laboratory will usually have on hand or have ready access to a portable survey meter capable of detecting low levels of radiation. The instrument is to be used for evaluating the radiation environment and monitoring personnel and work areas for contamination. Survey meters will be calibrated periodically. The Radiation Safety Officer performs this service routinely at one-year intervals.

I. Security: Radioactive materials must be secured against tampering, loss, unauthorized removal and theft when not in use. This may be accomplished by storing radioactive material in a locked container, e.g. refrigerator, or locking the room when left unattended for a length of time, which would prevent unauthorized entry and removal of licensed material.

J. Record Keeping Requirements:

1. The Radiation Safety Officer shall maintain all records required to satisfy requirements specified in the Rules and Regulations for Radioactive Materials (Chapter 391-3-17) by the GDNRR.
2. Radiation Safety Officer maintains a record of waste disposal from information provided by investigators.
3. Radiation Safety Officer will also maintain records of waste transferred to the licensed disposal contractor.
4. Individual users must keep records of receipt of licensed material and disposal to air, sanitary sewers and to waste disposal containers provided by the Radiation Safety Officer.
5. The Radiation Safety Officer shall maintain records of quarterly laboratory surveys. Authorized investigators shall maintain records of monthly surveys they conduct in their laboratories.

VIII. Emergency Procedures

Emergencies resulting from accidents in the handling of radioactive materials may vary from serious incidents involving high levels of radiation exposure or contamination to minor spills. It is often difficult to know immediately the extent of a hazard that has been caused by the accident. In an emergency the health and safety of personnel in the laboratory must be the primary concern.

A. Minor Spills: A minor spill involves little or no immediate radiation hazard to personnel.

1. Notify personnel in the area that a spill has occurred.
2. Restrict access to the contaminated area.
3. Confine or contain the spill immediately.
    a. Liquid spill - use protective gloves, and cover the spill with absorbent paper.
    b. Dry spill - use protective gloves; dampen absorbent paper and place over the spill.
4. Monitor involved personnel for contamination. Decontaminate if necessary. Record the results of the personnel monitored.
5. Clean up the spill. Use disposable gloves and remote handling tongs. Deposit clean up material into a plastic bag and then dispose into a segregated radioactive waste container. Continue decontamination using detergent and water until no removable activity is detected by smear survey, or as otherwise authorized by the Radiation Safety Officer.
6. Notify the Radiation Safety Officer, (off) ext: 3057. During non-working hours, weekends and holidays, dial (res) 898-0877.

B. Major Spills: A major spill could result in a significant exposure to personnel.

1. Notify all personnel in the area of the accident. Have personnel not involved in the spill to vacate the area.
2. Individuals who may have been contaminated should be taken to a nearby contamination free area for evaluation. Confine the movement of all personnel potentially contaminated to prevent the spread of radioactive material.
3. If personnel contamination is apparent, then take appropriate action. Remove contaminated clothing and place in plastic bags. Wash contaminated skin with mild soap and luke-warm water. See section - Radiation Protection Procedures; Subsection- Decontamination of Personnel for additional information. Document all personnel contamination survey results.

1) Cover the spill with absorbent pads. Prevent all access to the contaminated area. Wait for the arrival of or further instructions from Radiation Safety personnel.
2) Notify the Radiation Safety Officer - x3057. Radiation Safety Officer will monitor all persons involved for contamination and will recommend steps necessary for clean up.

C. Loss or Theft of Radioactive Materials: In case of loss or theft of radioactive materials, or suspected loss or theft, contact the Radiation Safety Officer immediately.

IX. Principles of Radiation Safety and Review of Current Knowledge of Radiation Effects

A. Atomic Structure and Radioactivity Structure of the Atom: All matter is composed of elements and all elements are composed of atoms. An atom is the smallest known unit of an element that can exist and still retain all the physical and chemical characteristics of the element. The atom is a combination of particles held together by balanced electromagnetic forces. The fundamental parts of the atom are the nucleus and the electrons. The nucleus is the extremely small core of the atom in which practically all of the atom's mass is concentrated. With the exception of the simple Hydrogen atom, all nuclei are composed of both protons and neutrons. The nucleus possesses a positive electrical charge. The electron is an extremely small particle with a mass about 2000 times less than that of the proton and neutron. It possesses one unit of negative electrical charge and rotates in an orbit at a relatively great distance from the nucleus. The following diagram of a helium atom depicts the general arrangement of an atom. Electron Orbits Rotating around the nucleus in distinct orbitals are the electrons. For an electrically neutral atom, the number of electrons in orbit is equivalent to the number of protons in the nucleus. All of the electrons present do not necessarily travel in the same orbital sphere, but, depending on the total number of electrons, certain groupings travel in different planetary orbits known as "electron shells." The electrons whirl at tremendous speed and probably would have the tendency to separate and fly off into space, except that the gravitational pull on them by the heavier mass of the nucleus, and the fact that opposite electrical charges attract, keep them a part of the atom's structure.

Atomic Number: The number of protons in an atom's nucleus is known as the "atomic number". It is the number of protons, which will determine which element the atom is. For example, atoms having 8 protons are the element Oxygen; atoms having 7 protons are Nitrogen; atoms with 6 protons are Carbon; etc.
Atomic Mass Number: The combined number of protons and neutrons in an atom's nucleus is known as the "atomic mass number". The number of protons and neutrons will determine which isotope of an element the atom is. For example, there are many isotopes of the element Oxygen, such as Oxygen-16, Oxygen-17 and Oxygen-18. Each of these Oxygen atoms has exactly 8 protons in the nucleus, but differing numbers of neutrons. The number of neutrons present in an atom's nucleus is the difference between the atomic mass number and the atomic number.
Radioactivity: The term "radioactivity" can be simply explained as "that change in the nucleus of an unstable atom which results in the spontaneous emission of ionizing radiation". It is believed that when an atomic structure attains the complexity of radium or uranium, for example, the internal electromagnetic forces are not sufficiently powerful in proportion to the mass of the atoms to hold the nuclei together. Thus, there is a slow but spontaneous disintegration of the atoms to more stable arrangements. As the nucleus disintegrates, there is a spontaneous release of energy. The energy is called "ionizing radiation", and it can be in the form of particles or electromagnetic rays. Thus we have "radioactive decay" - the process whereby an unstable, or radioactive, atom loses energy and becomes more stable. Currently throughout the U.S., the most common unit of measure used for an amount of radioactivity is the curie (Ci). By definition, one curie is that amount of radioactivity equivalent to 2.2 X 10^{12} disintegrations per minute (dpm) (or 3.7 X 10^{10} disintegrations per second (dps)). The curie is only a measure of an amount of radioactivity; it is not a measure of mass or weight. The curie is a relatively large unit of measure of an amount of radioactivity, therefore, the submultiples millicurie and microcurie are more **typically used:**

1 millicurie (mCi) = 1/1000 Ci or 10^{-3} Ci
1 microcurie (Ci) = 1/1,000,000 Ci or 10^{-6} Ci

The International System of Units (SI) measure for radioactivity is the becquerel (Bq). One becquerel is an amount of radioactivity equivalent to one disintegration per second (dps). This unit relates to the curie as follows:

1 Bq = 2.703 X 10^{-11} Ci
1 Ci = 3.7 X 10^{10} Bq

You can expect to see the activity on your stock vials of radioactive material expressed in either type of unit - curie or becquerel.
Radioactive Half-Life (t1/2) : Each radioactive isotope has its own unique rate of disintegration or "decay". Radioactive decay is a random process. It cannot be affected or altered by any known physical or chemical processes. Decay is random in that it cannot be predicted which particular

atoms are going to decay or when they will decay. However, the total number of atoms, which will decay in a specified period of time, is predictable. The term "radioactive half-life" is defined as "the amount of time required for one-half of the original radioactive atoms in a sample to disintegrate or decay". For each radioisotope, the half-life is constant. The units of half-life can vary from just a few seconds to tens of thousands of years. As a general rule of thumb, the passage of approximately ten to twelve half-lives is required before the radioactivity in a given sample can be considered to be effectively decayed.

<u>REFERENCE CHART FOR RADIOACTIVE DECAY</u>

No. of Half-Lives% of Original Activity Remaining No. of Half-Lives% of Original Activity Remaining

150%	70.78%
225%	80.39%
312.5%	90.20%
46.25%	100.10%
53.13%	110.05%
61.56%	120.02%

B. Ionizing Radiation: "Radiation" is energy in transit in the form of high-speed particles or electromagnetic waves. We encounter electromagnetic waves every day. They make up our visible light, radio and television waves, ultraviolet (UV), and microwaves. These examples of electromagnetic waves do not cause ionizations of atoms because they do not carry enough energy to separate molecules or remove electrons from atoms. These types of electromagnetic waves are referred to as "nonionizing radiation". "Ionizing radiation" is a form of energy, released during the disintegration of unstable atoms. Ionizing radiation is characterized by its ability to cause changes in the matter with which it interacts. In contrast to other forms of radiant energy, ionizing radiation imparts enough localized energy to the absorbing medium to cause ionization, as well as excitation, of the atoms and molecules with which it interacts. THESE ARE PROCESSES OF BIOLOGICAL INJURY. A high-energy particle or a photon of energy passing through matter is somewhat like a high-speed billiard ball passing through a large group of motionless billiard balls. As the particle or photon passes through the matter, it hits some of the atoms in its path. Since the volume and electrical field of the nucleus are very small when compared to the rest of the atom, most of the interactions are between orbital electrons and the incident particle or photon. "Ionization" is the process of being converted into electrically charged atoms or molecules ("ions"). This usually occurs through the removal of one or more orbital electrons from the atom or molecule. Whenever a particle or ray drives an electron out of its normal orbit we have an ionization process, since the remaining atom is no longer electrically balanced. The free electron and the positively-charged ion together are called an "ion pair". The term "specific ionization" refers to the number of ion pairs formed per linear centimeter along the path traveled by the ionizing radiation.

Energy Units Associated with Ionizing Radiation The energy required to produce a single ion pair is very small by ordinary standards. To get an idea of the amount of energy required, let us first define two small energy units: the erg and the electron volt. The erg is defined as "the amount of energy required to lift a mass of about 1 mg through a distance of 1 cm". To help put this into perspective, consider this: A 100-watt light bulb consumes about 1 billion ergs of energy every second.

The electron volt (eV) is the unit normally used for expressing the energy possessed by ionizing radiation. The electron volt is defined as "the amount of energy acquired by an electron as it falls through a potential difference of one volt". It is common to express the energy of ionizing radiations in thousands (keV) and millions (MeV) of electron volts. The electron volt, kev, and MeV are extremely small quantities of energy. We find that the erg is a much larger quantity than the MeV; in fact, one erg is equivalent to about 625,000 MeV. The minimum amount of energy required to produce a single ion pair is about 32 eV (for removal of an outer shell electron).

Types of Ionizing Radiations and Their Characteristics: There are two fundamental forms of ionizing radiation: electromagnetic and particulate. Electromagnetic radiation includes X-rays and gamma rays. Particulate radiation includes beta particles (electrons), protons, neutrons, alpha particles, and other atomic particles of varying mass and charge. Each specific type of ionizing radiation can be identified by its varying ability to penetrate matter and produce ionization. Most ionizing radiation will interact with matter via two basic methods: "collision" and "electrical field interaction". The specific way in which ionizing radiation interacts with matter depends on **four basic things:**

1) Mass of the ionizing radiation;
2) Electrical charge of the ionizing radiation;
3) Energy level of the ionizing radiation; and
4) Type of material the ionizing radiation is interacting with.

The following pages contain a brief discussion of the most common types of ionizing radiation. In order to maintain exposures as low as possible, each individual should be familiar with the type and energy of the radiation emitted by the radioactive material with which he/she is working.

Alpha Radiation: Alpha radiation is not encountered at SSU. Alpha particles typically originate from the radioactive decay of elements with a high atomic mass (i.e., atomic number >84). Alpha particles, composed of 2 protons and 2 neutrons, are extremely efficient ionizers due to their relatively large mass and high positive charge. They cannot travel very far, even in air, without interacting with matter by way of both direct collisions and electrical field interactions.

Since each interaction costs the alpha particle some of its kinetic energy, it gives up its energy in a short travel distance, and thus is easily shielded.

Because of its low penetrating power, alpha radiation cannot penetrate the outer layer of dead skin, and therefore is generally not considered to be an external radiation exposure hazard for personnel. Any material, even a single sheet of paper, is an effective alpha shield. It is extremely important to note, however, that from an internal point of view, alpha radiation is the most biologically damaging of all the types of radiation. Alpha particles taken inside the body can cause significant damage in very localized areas of tissue. Because they cannot travel very far, alphas will tend to impart all of their excess energy and cause intense ionization in small groups of cells.

Beta Radiation: In the physical sense, beta particles are virtually identical to an atom's orbital electrons. The differences are that betas originate from the atom's nucleus and also tend to travel with much greater velocity than do orbital electrons. Most beta particles are negatively-charged, however, in some instances, beta particles are emitted which are positively-charged ("positrons"). Because beta particles have very little mass, they can travel a greater distance than alpha particles before their energy is absorbed. However, the beta particle's energy is widely scattered into an erratic path through the absorbing medium. The single unit of negative or positive electrical charge yields a much lower specific ionization as compared to that of the alpha particle.

Experiments indicate that the ionization caused by beta radiation falls off exponentially with distance, and that the beta particle's travel range depends upon its initial energy and the density of electrons in the absorbing material. Dense shielding material, such as lead, will be less effective than a lighter material, such as plexiglass, in attenuating beta fields because of the greater number of electrons per unit mass. Beta radiation is primarily considered to be an internal radiation exposure hazard. However, personnel could receive significant skin doses if exposed to energetic beta particles without sufficient protective clothing and observing other appropriate radiological work practices. Exposure to the lens of the eye is also of concern.

Most of the commonly-used radioisotopes at SSU, as in most biomedical research laboratories, are beta emitters, like ^{32}P, ^{125}I, ^{14}C, and ^{3}H.

Radiation "Exposure" Vs. Radiation "Dose": Just as we measure temperature in the units of degrees Fahrenheit or Celsius, we have specific terms and units for radiation. For example, "exposure" is the term used to express the amount of radiation to which an individual is subjected and its unit of measurement is the roentgen (R). "Exposure rate" is the amount of radiation to which an individual is exposed in some time period, usually an hour. Thus the common unit of exposure rate is roentgen per hour (R/hr). Another term used when discussing radiation exposure is "dose". "Dose" takes into consideration the specific type of radiation involved and the relative effects of that radiation on the body. The dose is the cumulative effect of radiation actually received by an individual. The unit of measurement of dose is the rem. "Dose rate" is the amount of radiation received in some period of time, usually an hour. Thus the common unit of measurement for dose rate is rem per hour (rem/hr).

NOTE: The international (SI) unit for radiation dose is the "sievert" (Sv). 1 Sievert = 100 Rem.

C. Procedures for Minimizing Personnel Radiation Exposures: There are two categories of radiation exposure with which we are concerned: external and internal exposures. External exposures result from radiation sources which are located outside of the body. Conversely, internal exposures result from radiation sources located inside the body. Internal exposure is more biologically damaging than external exposure.

Control of External Exposure:

There are three fundamental principals used to minimize external radiation exposure: TIME, DISTANCE and SHIELDING.

TIME ===> By minimizing the amount of time spent in a radiation field, the total amount of exposure received will be minimized. Practical methods for reducing the time of exposure include:

- Preplan and rehearse work procedures. Before beginning any new procedures, develop a detailed plan for carrying out the steps. Practice operations to improve dexterity and speed before using radioactive materials.
- Organize and have readily available all the necessary materials, tools and equipment prior to beginning the procedure.

DISTANCE ===> By increasing the distance from a radiation source, the amount of exposure received will be reduced. Practical methods for maximizing distance from radiation sources include:

- Position the major portion of the whole body, including the head, as far as possible from radiation sources while working.
- Work at arm's length from radiation sources.
- Whenever possible use tools (forceps, tongs) to handle primary vials and other sources.
  * Do not work directly over open containers of radioactive materials.

SHIELDING ===> By placing appropriate shielding materials between personnel and sources of radiation, exposure rates and subsequent personnel exposures will be reduced.

- Store and work with strong beta emitters (like ^{32}P) and gamma emitters behind appropriate shielding. Be sure to consider all sides (top, bottom, front, back, & sides). Do not assume that the floor or a wall is adequate shielding. Personnel working in adjacent spaces may receive unnecessary and/or unmonitored exposures due to inadequate shielding.
- Unused radioactive material and samples shall be returned to well-shielded storage areas when not in use.

- Appropriate shielding shall be used for radioactive waste containers and storage areas.

COMMONLY-USED RADIOISOTOPES & SHIELDING GUIDANCE

Hydrogen-3 (^{3}H) ========> Half-life ....12.26 years
(tritium)
Beta emitter.....19 kev (max)
Beta range ......4.7 mm (0.19")
Carbon-14 (^{14}C) ========> Half-life ....5730 years
Beta emitter ....156 kev (max)
Beta range ....22 cm (8.6")
Sulfur-35 (^{35}S) ========> Half-life ....87.9 days
Beta emitter ....167 keV (max)
Beta range ....24 cm (9.6")
Calcium-45 (^{45}Ca) =======> Half-life ....163 days
Beta emitter .....257 kev (max)
Beta range ....48 cm (19")

The above radioisotopes, even in millicurie (mCi) amounts, do not represent a significant external exposure hazard due to the low penetrating power of the beta emissions. You must wear always-protective clothing (gloves and lab coat) to avoid skin and/or clothing contamination and to minimize the possibility of intake. Shielding of these work areas and waste collection containers is not generally necessary.

Phosphorus-32 (^{32}P) ======> Half-life ....14.3 days
Beta emitter ......1710 kev (max)
Beta range ....6 m (20')

Phosphorus-32 emits highly energetic beta particles. The radiation exposure rate at the mouth of an open vial containing 1 mCi in 1 ml of liquid is about 2600 mR/hr. This exposure rate is not significantly attenuated by air; therefore, use of shielding materials is necessary. The best type of material for microcurie (Ci) amounts of ^{32}P would be 1/4" to 1/2" thick lucite, plexiglass, or other plastic which will absorb the betas while creating little secondary radiation (bremsstrahlung).

For millicurie (mCi) amounts of ^{32}P, thin lead shielding (1/8" or more) should be added to the exterior of the plexiglass shielding to absorb the higher intensity secondary radiation.

Iodine-125 (^{125}I) ====> Half-life ....60 days

The unshielded radiation exposure rate at 1 cm from a 1 mCi point source of ^{125}I is 1400 mR/hr. The half-value for lead shielding (the amount of material which will reduce the intensity of the radiation field to one-half its original value) is 0.02 mm (0.001"). Store in containers surrounded by commercially available lead shielding. 0.15 mm of lead will reduce the radiation field intensity to less than 1% of its original value.

Chromium-51 (^{51}Cr) =====> Half-life .... 27.7 days

The unshielded exposure rate at 1 cm from a 1 mCi point source of 51Cr is 180 mR/hr. The half-value layer for lead shielding is 1.7 mm (0.067"). Store in containers surrounded by commercially available lead shielding. One-quarter inch (1/4") thick lead shielding will attenuate the radiation field to about 6% of the unshielded intensity.

X. Safety and Handling of Beta Emitters

A) The beta emitters most commonly used on campus are H-3, C-14, S-35, Ca-45 and P-32. The maxium energies of the betas emitted and their ranges in air are given in the table below:

Radionuclide	Emax (MeV)	Range in Air (cm)
^{3}H	0.018	Less than 1
^{14}C	0.155	28
^{35}S	0.167	33
^{45}Ca	0.254	51
^{32}P	1.71	635

B) The most hazardous, commonly used beta emitter on campus is P-32. Phosphorous-32 is used extensively in research and must be handled carefully. Phosphorous-32 emits beta particles with maximum energies of 1.71 Mev and average energies of 0.57 Mev. Significant dose rates may be experienced when handling P-32. For example, the dose rate at the surface of a 1 ml solution containing 1 mCi of phosphorous-32 is approximately 13 rem/min. The average dose rate to the hand while it is contact with a glass shipment vial containing 1 mCi of P-32 is 439 mrem/hr. As a final example, the average dose rate at a 10 cm distance from the side of a glass shipment vial containing 1 mCi of P-32 is 5 mrem/hr. Tritium, carbon-14, sulfur-35 and calcium-45 are not external radiation hazards.

C) Estimates of dose rates should be conducted before handling high-energy beta emitters, such as P-32. The dose rate estimates can be calculated using the equations below. These equations were taken from The Health Physics and Radiological Health Handbook (1984).

Equation 1- Dose Rate (rads/hr) at One Centimeter From a Point Source. DR 1cm ~ 200 x A where DR1cm= the dose rate at 1cm distance from the radioactive point source (rads/hr); and A= the quantity of radioactive material (mCi).

Equation 2- Dose Rate (rads/hr) in a Solution DRsol 1.12 EC/p where DRsol = the dose rate in solution (rads/hr);

E= the average beta particle energy (Mev);

C= the concentration of radioactive materials (Ci/cm^3); and

p= the density of the solution (g/cm^3).

Note: The dose rate is about one-half this value at the surface of the solution.

Follow the general lab practices and guidelines below to reduce radiation exposures:

1. Always keep radioactive and non-radioactive work separated as far as possible, preferably by maintaining rooms used solely for radioactive work.
2. Always work over a spill tray and in a ventilated enclosure (except with small (<1mCi) quantities of ^{3}H, ^{35}S or ^{14}C compounds in a nonvolatile form in solution).
3. Always use the minimum quantity of radioactivity compatible with the objectives of the experiment.
4. Always wear protective clothing, safety glasses and gloves when handling radioactive materials.
5. Always wash your hands and monitor yourself before leaving an area where radioactive materials are handled or stored.
6. Always work carefully and monitor the working area regularly to avoid ruining experiments by accidental contamination.
7. Always label containers of radioactive material clearly, indicating radionuclide, total activity, compound and date.
8. Never eat, drink, smoke or apply cosmetics in an area where unsealed radioactive materials are handled or stored.
9. Never use ordinary handkerchiefs to clean items or surfaces; use paper tissues and dispose of them as radioactive waste.
10. Never work with cuts or breaks in the skin unprotected, particularly on the hands or forearms.
11. Never pipette radioactive solutions by mouth.
12. In the event of a spill, it is essential to minimize the spread of contamination by adhering to the following steps:
    - Cordon off the suspected area of contamination. Ascertain, if possible, the type of contamination, i.e. the nuclide(s) involved (as it may be necessary to use breathing apparatus, protective clothing or other equipment).
    - Determine the area of contamination by monitoring, after taking the necessary precautions.
    - Decontaminate the area in convenient sectors by wiping and scrubbing, starting from the outer edge.
    - Ensure that a sector is clean by monitoring, before moving to another sector.
13. Film badges should be worn for all radioactive work except with Ci quantities of the low energy gamma emitters and radionuclides such as ^{3}H, ^{14}C and ^{35}S.
14. Use tongs or other remote handling equipment, where appropriate, to minimize dose to the extremities.

It is highly recommended that lab personnel handling millicurie quantities of P-32 use plexiglass shields to reduce exposure. Additional information on handling P-32 safely is provided in this manual.

Volatile Radioactive Material:

1. Handle volatile radioactive materials in fume hoods that are properly operating.
2. Volatile radioactive materials include, but are not limited to, those compounds that are labeled with H-3, S-35, C-14, and I-125

Note: The above steps will reduce the potential for ingestion and inhalation of radioactive materials.

Recommended Guidelines for the Safe Handling of Phosphorous-32

In General:

1) Use remote handling tools. Employ both low and high density shielding (low density nearest the source). Protect eyes from chemical splash and unnecessary radiation. Personnel handling millicurie quantities should wear safety glasses. (The attenuation factor of standard safety glasses is approximately,
2) Employ gloves to avoid direct skin contact with the radionuclide. Two pairs of gloves are often useful; the inner pair must be kept clean. If skin contamination is detected, promptly decontaminate with soft soap and plenty of water. If this is not successful, a suitable solvent may be selected if extreme caution is exercised not to injure the skin. To determine if skin contamination has resulted in a significant intake of activity, a urine sample should be submitted for analysis one hour later.

All personnel working with phosphorus-32 should use TLD monitoring devices. The Geiger-Muller (GM) tube is a useful detector for phosphorus-32 radiation. Prevent ingestion of phosphorus-32. Clean work area after each operation.

Recommended Laboratory Policies:

1. Ensure that two or more people are present in the laboratory when phosphorus-32 is handled.
2. Design and use equipment to assist in reducing all exposure.
3. Conduct frequent radiation surveys of all work areas where phosphorus-32 is used throughout the day and at the end of each workday.

XI. ALARA Policy:

It is the policy of the SSU that exposure to ionizing radiation can be maintained as low as practicable consistent with the teaching, research and service missions of the institution.

Radiological Operations Forms

1. Application for Possession and Use of Radiation Sources
2. Authorization for Possession and Use of Radiation Sources
3. Quarterly Inventory Form
4. Declaration of Pregnancy

STATEMENT OF TRAINING AND EXPERIENCE FOR USE OF RADIATION SOURCES AUTHORIZED USER

Name of applicant:				Date:
Birth date:	Social Security Number:			Sex:
Type of training:	Where trained	Duration of training	Formal course (Check)	On-the-job (Check)
1. Principles of radiation protection				
2. Radioactive measurements techniques and instrument				
3. Math basic to radioactivity				
4. Biological effects				

Experience with Radiation Sources:

Source	Amount	Where Used and Duration	Type of Use
1.			
2.			
3.			
4.			

Experience with Detection Instruments:

Type of Instrument	Radiation Detected	Use
1.		
2.		
3.		

Type and Quantity of Radiation Sources to be Used:

APPLICATION FOR POSSESSION AND USE OF RADIATION SOURCES

1. Applicant Name____Degree__________________

   SSU Position____ Full Time______ Other____________

2. Department____ Office Phone____________________

3. Laboratory No.______________________________________ Lab Phone______________________

This form must be typed or printed neatly with black ink.

4a. Source(s) to be used:	4b. Form:	5. Possession Limit Requested:

6. Proposed use and plan of investigation

7. Plan for personnel monitoring and radiation protection

8. Plan for disposing of radioactive wastes

_______As per procedures in the Handbook

Special procedures to be used:

Radiation Safety Officer Review	Radiation Safety Committee Review	9.
Date received: Date approved ________________________ Radiation Safety Officer	Date Received: Date approved: ________________________ Committee Chairman	____________________ ____/_________ Applicant /Date ____________________ Department Chairman

AMENDMENT APPLICATION FOR POSSESSION AND USE OF RADIATION SOURCES

Authorized User:___________________________ Authorization No. _______________

Department: ______________________________ Lab Rm. No.: _______________

This form must be typed or printed neatly with black ink.

1a. Source(s) to be used:	1b. Form:	1c. Possession Limit Requested:
2. Proposed use and plan of investigation		
3. Plan for personnel monitoring and radiation protection		
4. Plan for disposing of radioactive wastes if different than the procedures in the Handbook		
Radiation Safety Officer Date received: Date approved: ____________________ Radiation Safety Officer	Radiation Safety Committee Review Date received: Date approved: ____________________ Committee Chairman	5. Signatures ____________________ Applicant ____________________ Department Chairman

\

AUTHORIZATION FOR POSSESSION AND USE OF RADIATION SOURCES

1. Authorized User: 2. Department: 3. Location:		
4. Radiation source:	5. Form:	6. Quantity authorized: (mCi)

7. Approved use:

Date:________________________ ____

Radiation Safety Officer

STATEMENT OF TRAINING AND EXPERIENCE FOR USE OF RADIATION SOURCES
RADIATION WORKER [Individual user]

Name of Radiation Worker:				Date:	
Birthdate:		Social Security Number:			Sex:
Name of Authorized User:				Department:	

Type of training:	Where trained	Duration of training	Formal course (Check)	On-the-job (Check)
1. Principles of radiation protection				
2. Radioactive measurements techniques and instrument				
3. Math basic to radioactivity				
4. Biological effects				

Experience with Radiation Sources:

Source	Amount	Where Used and Duration	Type of Use
1.			
2.			
3.			
4.			

Experience with Radiation Sources:

Type of Instrument	**Radiation Detected**	**Type of Use**
1.		
2.		
3.		

Type and Quantity of Radiation Sources to be Used:

Rad Worker Location:	Rad Worker Signature:
Rad Worker Phone Number:	
Date Recd: Date Eval:	Authorized User Signature:
DRS:	

LABORATORY RADIATION SAFETY ORIENTATION CHECKLIST

Worker Name:____

Lab Location____________________________________

1. **General Use of Laboratory**____
____

2. **Radioactive Material Use in Laboratory:**

   Describe RAM used (type of emitter, chemical form and general procedures):________________

   ____

   ____

3. **Safety Precautions** (check if reviewed, or NA = Not Applicable)

   __ gloves___lab coats___absorbent paper___trays

   ___areas of use defined __ shielding used___ hood use___wipe tests

   ___meter surveys___personnel monitoring___no mouth pipetting

   ___no eating, drinking, smoking ___no gum chewing___no cosmetics application

   Other lab-specific safety precautions:____

   ____

4. **Emergency Procedures** (check if reviewed, or NA = Not Applicable)

   __General Procedures___Fire___Minor Spills___Major Spills

   ___Notifications ___Emergency Procedure Posted___Incident Reporting Requirements

   Other notes:____

   ____

REPORT OF LEAK TEST OF SEALED SOURCE

Pursuant to the conditions of the license to the Savannah State University or to the applicable sections of the GDNRR, a leak test has been performed on the source or sources identified in items 4, 5 & 6 below and this report satisfies the condition of the referenced License and Regulation.

1. Name of authorized user:	Date of test:
2. Department:	Authorization no:
3. University address:	License no:

4. Radioactive material contained in sealed source (element and mass number).	5. Quantity of radioactive material contained.	6. Identification code (serial number or location).

7. Results of the test:
   - ☐ The source was found to have less than 0.005 μCi of removable contamination (0.05 μCi, if applicable).
   - ☐ The source was found to have more than 0.005 μCi of removable contamination (0.05 μCi, if applicable).

   Comments:

   If the results of the test indicate a removable contamination in excess of 0.005 μCi, the source SHALL be taken from service immediately and arrangements made for decontamination or disposal.

8. Equipment used for the test:
   - ☐ For β and γ contamination:

     Minimum detectable contamination by use of this system is:

   - ☐ Other as follows:

Date of report　　　　　　　　　　　　　　　　　　Test performed by

RADIOACTIVE MATERIALS DELIVERY FORM

Date Received:______________________________

Company:__________________________________Shipper:________________________________

Isotope: ____________________Compound:____

Activity: __________________________________Number of Packages:__________

Package Dose Rates @ Surface:__________________@ 1 m:_________________

Container Dose Rate: __________________________Removable

Contamination:____________________

DRS Signature: ______________________________Date:___________________________________

Receiver Signature:_____________________________________

Date:_________________________

Comments:

Wipe Test Results:

___Beckman LSC Model

___Wipe of Outer Package: _____________________dpm

___Instrument Bkgd: _________________________dpm

___Net: __________________dpm

___Other: Make__________Model___________________S/N_____________efficiency________

QUARTERLY INVENTORY FORM

Authorized User's Name: ____

Radioactive Materials Quarterly Inventory Printed:

Radio-nuclide	Compound	Vendor	Date Rec'd	mCi Rec'd	On hand mCi	In lab waste mCi	Σ mCi to CBARS

TOTAL INVENTORY:

Notes:

Waste Transfers during quarter:

DATE Radionuclide Amounts (indicate if transfer activity is decay corrected)

DATE_______________SIGNED____

Pick Up No. __________

RADIOACTIVE WASTE PICK UP FORM

Send completed forms to Radiation Safety Officer, DG-126

Date ______________ Department/School Name: ____

Waste generator's name: ____ Telephone: _____________________

Print name of person authorizing charges and pick up: ____

Signature of person authorizing charges and pick up: ____

Location of waste for pick up: Bldg: ________________ Room: ______________ Other: ___________________

If waste requires immediate attention, please explain: ____

____

Container					
Isotope					
μCI					
Dose Rate 1 Meter					
Wipe Inst					
Disposal Date					
Disposal Mode					
Disposal by					
Mixed Waste (Y or N)					
Characteristic					

Hazardous Chemicals Present (include chemical names and % by weight (kg) of volume (L)):

____

____

Comments:

____

Picked up by ___________________________________ Date _____________________

RADIOACTIVE MATERIALS INTERNAL TRANSFER FORM

Transfer Date:_____________________________ To (Authorized User Name):______________________________

From (Authorized User Name):____

Isotope:________________________Compound____

Activity:____

Comments:____

____

Signatures:

Authorized User Transferring:_______________________________________Date:___________________________

DRS:____Date:___________________________

Authorized User Receiving:____Date:___________________________

DECLARATION OF PREGNANCY

This is to officially inform the Savannah State University Radiation Safety officer that I am pregnant. The following information is being provided to assist in determining if additional monitoring or precautions are necessary.

Radiation Worker:____SSN________-______-________

AU:____ Rad Worker's Telephone:__________________

Radionuclides that have been used or will be used during the pregnancy:_____________________________

Radiation Producing Devices that have been used or will be used during pregnancy:

____

The following radionuclides are present in the laboratory I frequent, but are not used by me:

____

Estimated conception date: _______/_______Estimated delivery date:_______/_______
(month/year)

I understand that upon declaration of pregnancy, I may speak with Radiation Safety Officer about my radiation exposure. I understand that my occupational radiation dose during my entire pregnancy will not be allowed to exceed 0.5 rem (5 millisieverts) (unless that dose has already been exceeded between the time of conception and submitting this letter). I also understand that meeting the lower dose limit may require a change in job or job responsibilities during my pregnancy.

If I find out that I am not pregnant, or if my pregnancy is terminated, I will promptly inform the Radiation Safety Officer in writing that my pregnancy has ended.

Name:______________________________________ ____
(Print or type) (Signature)

Date: ____

For Use by the Radiation Safety Officer:

Date received:_____________________________________ Consultation date:___________________________

Individual badged: Y_____N_____Badge No.____________

Notes:____

____