CLEMSON UNIVERSITY RADIATION SAFETY

and

WASTE MANAGEMENT MANUAL

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I. DEFINITIONS OF TERMS USED IN THIS MANUAL

ALARA - Acronym for "As Low As Reasonably Achievable", a basic concept of radiation protection that specifies that radioactive discharges to the environment and radiation exposure to personnel be kept as far below regulatory limits as feasible.

Airborne radioactive material - any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors or gases.

Airborne radioactivity area - (1) any room, enclosure, or operating area in which airborne radioactive material exists in concentrations in excess of the amounts specified in RHA 3.53, Appendix B, Table I, Column 3 of S.C. DHEC Radioactive Materials Regulation 61-63 title A ; or (2) any room, enclosure, or operating area in which, averaged over the number of hours in any week during which individuals are in the area, exceed 25 percent of the amounts specified in RHA 3.53, Appendix B, Table I, Column 3 of Radioactive material Regulations 61-63 Title A.

ALI (Annual Limit on Intake) - The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rem (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue.

BRH - As used in this manual: South Carolina Department of Health and Environmental Control - Bureau of Radiological Health.

Calendar quarter - not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year shall begin in January; and subsequent calendar quarters shall be such that no day is included in more than one calendar quarter or omitted from inclusion within a calendar quarter. No licensee shall change the method observed by him of determining calendar quarters except at the beginning of a calendar year.

Contamination - The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

Contaminated area - Any area where there exist loose surface (removable) contamination greater than or equal to:

1. 200 disintegrations per minute beta/gamma or
2. 20 disintegrations per minute alpha

Controlled Area - a defined area in which the occupational exposure of personnel to radiation or radioactive material is under the supervision of an individual in charge of radiation protection.

Curie (Ci) - The basic unit used to describe the intensity of radioactivity in a sample of material. That amount of radioactivity that will disintegrate of the rate of 3.7×10^{10} disintegrations per second or 2.22×10^{12} disintegrations per minute (dpm).

Commonly used fractions of the curie:

1. picocurie (pCi) - one trillionth part = 2.22 dpm
2. nanocurie (nCi) - one billionth part = 2.22×10^3 dpm
3. microcurie (µCi) - one millionth part = 2.22×10^6 dpm
4. milliecurie (mCi) - one thousandth part = 2.22×10^9 dpm

DAC (Derived Air Concentration) - The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI.

dpm - The number of radioactive disintegrations per minute.

Dose rate - The radiation dose delivered per unit of time. Measured, for example, in rem per hour (rem/h).

Exposure – 1. The absorption of radiation or ingestion of a radionuclide. Acute exposure is generally accepted to be a large exposure received over a short period of time. Chronic exposure is exposure received during a lifetime.

2. Measure of the ionization of air due to ionizing radiation from photons, that is, gamma rays and X-rays. SI unit of exposure is Coulomb per kilogram (C/kg), traditional unit is Roentgen (R).

"Bureau" or BRH - the South Carolina Department of Health and Environmental Control - Bureau of Radiological Health.

Gamma ray - High energy, short wavelength electromagnetic radiation emitted from the nucleus of an atom. Gamma radiation frequently accompanies alpha and beta emissions.

Half-life - The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form.

Half value thickness - The thickness of any given absorber that will reduce the intensity of a beam of radiation to one-half its initial value. Tenth value thickness - same as above but with reduction to one-tenth the original value.

High Radiation Area - means any area, accessible to individuals, in which there exists radiation at such levels that the whole body could receive in any one hour a dose in excess of 100 millirem.

Ionizing radiation - Any radiation capable of displacing electrons from atoms or molecules,

thereby producing ions: alpha, beta, gamma, X-rays, and neutrons.

Isotope - One of two or more atoms with the same number of protons, but different numbers of neutrons in their nuclei. Isotopes have very nearly the same chemical properties, but different physical properties (for example carbon-12 and -13 are stable, carbon-14 is radioactive). For the purposes of this manual the word "isotope" means "radioactive or radio-isotope".

License - except where otherwise specified, means either a general license or specific license issued pursuant to DHEC Radioactive Material Regulations.

Natural radioactivity - radioactivity of naturally occurring nuclides.

Radionuclide – same as radioisotope. For the purposes of this manual the word "nuclide" means radionuclide or radioisotope.

Occupational dose - dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under appropriate regulations, from voluntary participation in medical research programs, or as a member of the public.

Primary use area - any area such as a table, bench top or portion of a bench top that is set aside for the staging and manipulation of potentially contaminated items or unsealed source material. These areas will be delineated by placing yellow and magenta tape around the perimeter of the area and a readily visible sign bearing the radiation trifoil and the words "CAUTION CONTAMINATED AREA". Use of these areas will assist in segregation of contaminated and non-contaminated items and help to minimize materials stored in the fume hood.

Personnel monitoring equipment - devices designed to be carried or worn by an individual for the purpose of measuring the dose an individual receives (e.g. film badges, film rings, pocket chambers, pocket dosimeters, thermoluminescent dosimeters, etc.).

Radiation - For the purposes of this manual the word “radiation” means “ionizing radiation”, and does not include non-ionizing types of radiation (microwave, visible, IR or UV light, radiowaves, etc.)

Radiation Area - any area, accessible to individuals, in which there exists ionizing radiation at such levels exceeding those listed in Title A, RHA 1.2.24. Any area in which there exist ionizing radiation at such levels such that the whole body could receive in any one hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of

100 millirem.

Radiation Safety Officer (RSO) - any person directly responsible for protection against radiation. At Clemson the RSO is Konstantin Povod.

Radioactive material - any material, solid, liquid, or gas, which spontaneously emits ionizing radiation.

Restricted area - any area to which access is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used for residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

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.

Smear - A piece of filter paper or cloth disk which is wiped over a surface and analyzed to determine if the surface is contaminated with loose radioactive material (reported in units of dpm / 100 $cm^{2)}$.

Source of radiation - any radioactive material, or any device or equipment capable of producing or emitting radiation.

Survey - an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and/or equipment and measurements of levels of radiation or concentrations of radioactive material present.

Unrestricted area - any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

Whole body - the entire body, or a major portion thereof, or the head and trunk, or the active blood forming organs, or the lens of the eyes or the gonads. Whole body does not refer to the skin of the whole body.

UNITS OF RADIATION DOSE.

Dose - the quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body. When these regulations specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use. Definitions of units as used in DHEC regulations are set forth in the following

paragraphs of Title-A 1.3.2 and 1.3.3

Rad - Radiation Absorbed Dose: a measure of the dose of any radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per 1 gram of tissue. (One millirad [mrad] = 0.001 rad)

Rem - a measure of the dose of any radiation to body tissue in terms of its estimated biological effect relative to a dose of one rad of gamma- or X-rays. (One millirem [mrem] =0.0010 rem.) The relation of the rem to other dose units depends on the biological effect under consideration and upon the conditions of irradiation. For the purpose of these regulations, any of the following is considered to be equivalent to a dose of one rem:

A dose of 1 R due to X - or gamma radiation;
A dose of 1 rad due to x -, gamma, or beta radiation;
A dose of 0.1 rad due to neutrons or high-energy protons;
A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye

DEFINITIONS FOR RADIOACTIVE WASTE SECTION

RADIOACTIVE WASTE: Any waste material that contains:

1. Radioactively contaminated laboratory trash such as glassware, paper, lab clothing, gloves, culture dishes, syringes, etc.

2. Animal carcasses containing residual radioactive tracers.

3. Sealed radioactive sources used for instrument response checks or research. Notify the RSO before disposing of any sealed sources. Do not dispose of sealed sources in the regular laboratory rad waste. There are special requirements for their disposal.

4. Aqueous or organic solutions containing radioactive contaminants.

LIQUID RADIOACTIVE WASTE - Waste containing radioactive materials in aqueous or organic solutions.

DRY RADIOACTIVE WASTE - Dry laboratory trash to include: paper, gloves, glassware, utensils, etc.

LIQUID SCINTILLATION WASTE - Scintillation solvents, fluors and radioactive material and/or the containers that held them.

SHORT HALF-LIFE WASTE - Wastes containing radioactive materials with half-lives of

65 days or less.

LONG HALF-LIFE WASTE - Wastes containing radioactive materials with half-lives of greater than 65 days.

MIXED WASTE - contains both hazardous waste (as defined by RCRA and its amendments) and radioactive waste (as defined by Atomic Energy Act and its amendments).

II. INTRODUCTION

License to use Radioactive Material

The State of South Carolina is authorized by the U.S. Nuclear Regulatory Commission to regulate the use of Radioactive Materials within the state. Clemson University is licensed by the S.C. Department of Health and Environmental Control (DHEC) under Radioactive Materials Regulation 61-63 Title-A to possess and use radioactive materials (License #540). It is the responsibility of the Radiation Safety Committee (RSC), Radiation Safety Office, the Responsible Investigators, and the end users to ensure that all conditions of this license, as well as all applicable state and federal radioactive material regulations are met.

Radioactive materials are used at University facilities in support of a variety of research and teaching activities. Radioactive materials and radiation producing equipment are important tools used in all of the scientific disciplines pursued at the University.

Both Federal and State governments regulate the possession and use of radioactive material and radiation sources. Radioactive source material is controlled in accordance with rules and regulations contained in the South Carolina Department of Health and Environmental Control (S.C. DHEC) Regulation 61-63 Radioactive Materials (Title A). The University is authorized to possess and use radioactive materials in accordance with the limitations and precautions specified in the University's Broad Scope Radioactive Materials license #540. In order to qualify for issuance of these licenses, the University has committed to certain license conditions in its application to possess and use radioactive materials. It is important to note that these practices and procedures, which are committed to in our license applications, became conditions of use upon the approval of the licenses, and carry the weight of law.

One of the special conditions of license approval is establishment and maintenance of a Radiation Safety Committee (RSC). The Code of Federal Regulations Title 33 and South Carolina Title-A regulations both require that a Radiation Safety Committee composed of such persons as a radiation safety officer, representatives of the executive management and persons trained and experienced in the safe use of radioactive materials be formed as a prerequisite to issuance of a Type A Radioactive Materials License of Broad Scope. License conditions specify that the RSC is the final authority in all matters pertaining to the possession and use of radioactive materials.

The University's Radiation Safety Officer (RSO) serves as an agent of the RSC and has developed a radiation safety program to assure compliance with the provisions the license. This program is designed to protect the health and safety of University employees, members of the general public, and the environment from the potentially harmful effects of ionizing radiation. It is University policy to maintain radiation exposure to personnel and the environment "**as low as reasonably achievable**" (ALARA).

This "Radiation Safety Manual" sets forth the rules and procedures of the Radiation

Protection Program. Users should become familiar with the requirements and guidelines delineated in the Manual. These requirements and guidelines are intended to assist the end user of radioactive materials and aid the University at large in meeting the regulatory compliance commitments relative to our authorization to possess and use radioactive materials.

The Radiation Safety Office performs periodic inspections of areas in which radioactive materials and/or radiation producing equipment is stored and/or used. Inspections are performed in order to ensure compliance with the conditions and limitations of the University's Radioactive Materials Licenses, and with State Regulations Title A and Title B, pertaining to radioactive materials and radiation producing equipment respectively. Violations of established rules, regulations and procedures may result in the loss of privilege to use radioactive materials or radiation producing equipment as well as cause undue hazards to both the user and personnel in surrounding work areas.

Radiation safety depends on each user following the guidelines and procedures described in the Radiation Safety Manual. Please note that nothing in this Manual or the Radiation Safety Program proper relieves anyone from meeting the requirements and procedures of other programs of Research Safety to include chemical hygiene and hazardous waste management.

This Manual has two objectives:

1. To provide information to the Responsible Investigators (RI) and the individuals who work under his/her direction, and to standardize the practices and procedures for the safe use of radioisotopes, and

2. To provide explicit directions on how to properly handle the radioactive wastes which are generated as a result of the use of radioactive materials.

The Manual is divided into two parts that deal with each objective. Part one addresses the radiation safety program, protective measures, and provides information on radiation protection. Part two is dedicated to the radioactive waste minimization and management.

For more information, please contact the Clemson University Radiation Safety Officer, Konstantin Povod at 656-3516 or kpovod@clemson.edu. The Radiation Safety Office is located at 391 College Ave., Suite 104. Radioactive Waste Facility is located on Lake Dr. near the Waste Treatment Plant.

Copies of the Radiation Safety Manual, as well as other reference materials concerning the safe use of radioactive materials and radiation exposure may be obtained from the Radiation Safety Office. Consult the RSO and refer to Title A: Radioactive Material Regulation 61-63 issued by the S.C. Bureau of Radiological Health for explanations concerning the regulations pertaining to the use of radioactive materials.

PART ONE: RADIATION SAFETY PROGRAM

III. RADIATION SAFETY PROGRAM

Individuals involved in the radiation safety program at Clemson University include: Members of the Radiation Safety Committee (RSC), the Radiation Safety Officer (RSO) and staff, Responsible Investigators, Authorized Users and Radiation Workers.

Prospective Responsible Investigators apply to the RSC for authorization to use specific radioactive isotopes and / or radiation producing machines. By applying for and accepting authorization the Responsible Investigator assumes responsibility for how the isotopes or radiation producing machines are used in the research laboratory or in other authorized places of use under their supervision. The Responsible Investigator must establish a sound and current radiation safety program for all users under his/her direction. The RSC requires that such a program be outlined in the application for authorization to possess and use radioactive source material or radiation producing machines. Once approved, the tenants of the application become local conditions of use. The program should include certain elements that are described in the following sections.

A. Responsibilities of the Radiation Safety Committee

The Committee has the authority to define the policies, procedures, and standards governing the use of sources of radiation at all University facilities, to include approval of all Responsible Investigators. The RSC is the final authority in all matters relating to the safe possession and use of radioactive materials and radiation producing equipment.

The RSC may terminate the authorization to possess and use radioactive materials and/or other sources of radiation in a research study, and/or place restrictions on the use of radiation by a Responsible Investigator.

B. Responsible Investigator Duties and Responsibilities

1. Who is a Responsible Investigator?

The Radiation Safety Committee (RSC) and the Radiation Safety Officer (RSO) issue "authorizations" to qualified personnel permitting them to possess and use sources of radiation in University facilities. These personnel are called Responsible Investigators (RI). The RI, usually a faculty member, shares the legal responsibility for the safe handling of radioactive material or radiation producing devices under their jurisdiction. All university personnel and students directly involved in the use of sources of radiation conduct their operations

under the supervision of an RI.

2. Initial Authorization to use radioactive materials and radiation producing devices

Initial approval is obtained by submitting an application for authorization to the Committee on forms available through the Radiation Safety Office. The application will describe such items as:

- the facility or areas where the radioisotopes/radiation will be used,
- the radioisotope(s) or other sources of radiation which will be used, and
- procedures and work practices which will be followed.

3. Condition of Authorizations to Use Radioactive Material

An authorization defines for the Investigator:

- radionuclides or radiation producing equipment that may be used;
- allowable possession limit of each radionuclide;
- how the radionuclides may be used;
- which laboratories or areas that are authorized for used;
- the survey schedule of each lab;
- the required record keeping in the lab;
- any special conditions of authorization;
- lab personnel, “authorized users” and/or "radiation worker trainees", who may use radionuclides or operate radiation producing equipment.

4. Responsibility of Responsible Investigator (RI)

The Responsible Investigator shares the legal responsibility for the safe use of radioactive materials and/or radiation producing devices. The Responsible Investigator:

- Administers and enforces safety rules and regulations established by the RSC and stated in the University’s Radiation Protection and Waste Management Manual which are necessary to the radiation safety program in the areas within the scope of their authority.

- Ensures that personnel under their supervision are familiar with standard operating procedures specific to the authorized use area and for the radioisotopes in use and provide supervision

adequate to ensure that these procedures are followed

- Performs or cause to be performed radiation / contamination surveys sufficient to demonstrate control of radioactive materials or radiation producing devices possessed and used under their authorization.

- Ensures that all employees working with, or in the vicinity of radioisotopes or radiation producing devices are properly trained, informed, and monitored.

- Informs the Radiation Safety Office of additions or deletions of personnel working with radioisotopes or radiation producing devices.

- Reports promptly to the RSO any condition that may lead to or cause a violation of radiation safety regulations, which could cause unnecessary personnel exposure to radiation and/or could cause the unplanned release of radioactive materials into the environment.

- Maintains an inventory of all radioisotopes in the RI's possession

- Properly label and secure all radioactive materials or radiation producing devices from unauthorized access or removal.

- Provides a survey meter and/or other detection equipment suitable for detection of the radiation emitted from the isotopes or equipment being used and which is calibrated at least annually.

- Assures designation of a responsible individual to oversee radioisotope work during short absences, and a "stand-in" RI during periods of extended absences (greater than 60 days).

5. How to Amend an Authorization

The RI may request amendments to an authorization such as increasing activity or isotopes possessed or adding additional laboratory space by contacting Radiation Safety Office:

Rad Safety Officer:	656-3516, kpovod@clemson.edu,
Asst. Rad Safety Officer:	656-7165, price3@clemson.edu

C. Radiation Worker Duties and Responsibilities

All University personnel who handle radioactive material or who are

occupationally exposed to radiation during their employment or study are “Radiation Workers”. Radiation workers may be Responsible Investigators, graduate students, undergraduate students, technicians, post-doctorates, visitors, or any other individual who handles radioactive material or is exposed to radiation.
Individuals who use radioactive materials must assume that certain responsibilities are inherent in their work. The individual worker is the "first line of defense" in protection of people and the environment from the possible harmful effects of exposure to radiation. Since the workers, themselves, are the direct handlers of the radioactive material, the final responsibility lies with them for safety and compliance with applicable laws and regulations. For this reason, it is critical that they be aware of the risks, safe practices and requirements for use of radioactive materials.

1. Responsibilities of Radiation Workers

- Each worker must meet the radiation safety training requirements. Workers are prohibited from handling radioactive materials without line of sight supervision until this requirement has been met.

- Radiation workers are responsible for following the rules, regulations, and Radioactive Material License conditions outlined in this manual.

- Radiation workers must wear their assigned radiation monitoring equipment during the use of radioactive materials or radiation producing equipment.

- Radiation workers must keep their radiation exposure ALARA (As Low As Reasonably Achievable).

- The user must monitor radiation work areas after each use of unsealed radioactive material – at least daily after use. It is the responsibility of the worker to clean any spills or contamination that is found in their work area.

- No changes in experimental standard operating procedures are to occur without the approval of the Responsible Investigator.

- Any abnormal occurrence must be reported immediately to the Responsible Investigator, such as spills, significant contamination, theft or loss of radioactive material, suspected internal uptakes, equipment failure, loss of personnel dosimeter, or unplanned release of radioactive materials. If the RI cannot be reached, contact the Radiation Safety Office.

- Radiation workers are responsible for returning their personnel dosimeter on time and reporting any loss or contamination of the dosimeter to the Radiation Safety Office.

- Each new radiation worker is responsible for informing the RSO of any occupational exposures to ionizing radiation that have occurred as a result of previous employment.

- He/she is responsible for checking hands, feet, body and clothing for radioactive contamination after each use of unsealed source material, or upon exit from areas with concentrations of loose surface contamination greater than or equal to 200 dpm/100 cm^2 β/γ or greater than or equal to 20 dpm/100 cm^2 α.

- Ensuring that items are checked for contamination before removal from an approved radioactive materials use area.

2. Classifications of Radiation Workers under the supervision of the RI

a. Authorized User (AU)

An Authorized User is a radiation worker who attended classroom Initial Radiation Safety Training, is current on Annual Refresher Training, received instructions from RI on proper procedures applicable to the project s/he is working on, is listed on the project authorization and has sufficient experience in the use of radioactive material and radiation protection practices.

An Authorized User may supervise Radiation Worker Trainees and may instruct them on proper procedures and precautions.

An Authorized User assists in the day-to-day management of the work that is conducted under an authorization and may be formally designated by the RI as an alternate or area supervisor.

b. Radiation Worker Trainee

“Radiation Worker Trainee” category is created in order to accommodate individuals who are to work on a radioactive material project for a short period of time, or who need to join a project before completing classroom training, which usually occurs only three times a year, in the beginning of each semester. Radiation Worker Trainee may use radioactive

material before completing classroom training under the following conditions:
S/he:

- Reviewed this Manual and the project authorization documents;
- Received instructions from the RI or AU on proper radioactive material use and safety procedures;
- Was added to the project by completing form R-003 (see below);
- May only use radioactive material under direct supervision by the RI or AU.

3. How to Add a New Radiation Worker

Notify the RSO of the addition of a new radiation worker by submitting a form R-003 *Request to Add an Individual to a RAM Project* to the Radiation Safety Office via fax, mail, or e-mail. The form has to be signed by the person being added to the project and by the RI.

4. Training of Radiation Workers

One of the most important conditions of the University's radioactive license is that all radiation workers at University facilities must have radiation safety training. If an individual does not comply with this requirement, the Responsible Investigator is asked to restrict that person to line of sight supervision until training is satisfied.

a. Classroom training

Classroom training will normally be scheduled at the beginning of the fall, spring, and summer semesters. Additional classroom sessions may be added if there are personnel who need training between regularly scheduled classes. Classroom training is followed by the quiz intended to evaluate understanding of the presented material. Passing grade for this quiz was set by the RSC and is currently 60%.

b. Annual refresher training

All active Radiation Workers have to take Annual Refresher Training. This may be accomplished by attending a classroom training session, or online. Annual refresher training requires

taking and passing a quiz.

D. Responsibilities of the Radiation Safety Officer

1. Administration of the day-to-day activities of the Radiation Safety Office.

2. Serving as a permanent member of the RSC, reviewing for approval / disapproval all applications for the use of radioactive materials and / or equipment capable of producing ionizing or non-ionizing radiation.

3. Development and maintenance of the University's Radiation Safety Program, and ensuring that the program meets all applicable regulatory and license commitments.

4. Provision of liaison with appropriate University administrative offices, project investigators, other institutional committees or boards, and various regulatory and funding agencies.

5. Supervision of all aspects of the radiation detection and measurement and protective activities and related record-keeping activities to include: personnel monitoring, lab audits, radiation / contamination surveys, radiological waste disposal, and instrument calibration.

6. Supervision of acquisition and inventory control of all radioactive materials and / or machines capable of producing radiation.

7. Training and consultation with users or potential users of radioactive materials and/or radiation producing machines concerning proper practices and procedures to insure safe use.

IV. GENERAL SAFETY RULES FOR USE OF RADIOACTIVE MATERIALS

All personnel who work with radioactive materials are responsible for protecting themselves and others from any radiation hazards arising from their work. Good housekeeping and careful laboratory techniques are the primary means of preventing the spread of contamination and preventing the internal uptake of radioactive materials into the body. The following rules must be observed.

1. Knowledge of Proper Procedures

All persons who work with radioactive materials shall be fully aware of the procedures specified in this Manual and be instructed in matters of radiological safety. Copies of this Manual and other technical data pertaining to radiation safety are available through the Radiation Safety Office. It is the responsibility of the RI to ensure that all personnel working under his/her supervision have read and

understand the contents of this Manual.

2. Eating and Drinking

Eating, drinking, smoking, the application of cosmetics, and other similar activities that could lead to the internal uptake of radioactive contamination, are prohibited in areas where unsealed radioactive materials are used or stored. One's hands should always be washed after handling radioactive materials, especially before eating.

3. Housekeeping

High standards of cleanliness and good housekeeping must be maintained in all laboratories where radioactive material is present.

4. Janitorial Staff

Janitorial personnel shall not empty any containers or otherwise remove any material marked as "Radioactive Material". Janitorial staff will perform their duties such as mopping in “clean” areas (meeting unrestricted release limits for removable contamination) only. The RI or designated radiation worker shall be responsible for all housekeeping otherwise.

5. Glassware and other Utensils

Contaminated glassware and other utensils shall be segregated from other laboratory glassware or utensils and will be labeled with tape or tags bearing the radiation trefoil and the words "CAUTION RADIOACTIVE MATERIAL".

a. Staging Areas for contaminated articles
Staging areas should be used to segregate clean from contaminated material. This "staging area" may be a table, an entire bench top or a portion of a bench top, and should be delineated by placing yellow and magenta tape or rope around the perimeter of the area, and a sign bearing the radiation caution symbol and the words "CONTAMINATED AREA".

b. Although the entire laboratory is a "RADIOACTIVE MATERIALS AREA" and any item within the lab has a potential for becoming contaminated, items within Staging Area will be considered to be contaminated and should be surveyed before being removed to clean areas of the lab or before being removed from the lab proper.

6. Containers

Radioactive materials will not be left in uncovered containers. Glass containers should be placed inside larger break-resistant secondary containers (or inside fume hoods). Any container of licensed material shall bear a durable, clearly visible label identifying the radioactive contents so that individuals handling or using the containers or working in the vicinity may take precautions to avoid or minimize exposures.

a. At a minimum, the label will bear the radiation caution symbol and the words "CAUTION-RADIOACTIVE MATERIAL".

7. Work Surfaces

Disposable absorbent pads or lipped trays will be used to protect work surfaces and to confine spills. Work with radioactive materials shall be performed in ventilated fume hoods if the manipulation of such materials involves any possibility of airborne contamination.

a. Whenever possible, chemical procedures are to be carried out with all of the equipment in a tray containing absorbent paper, which has a volume large enough to accommodate twice the experimental volume in the event of an accident.

b. Heating and boiling of radioactive solutions, mechanical mixing and/or grinding, and work with radioactive iodine will take place in a fume hood with an average capture velocity of at least 100 linear ft/sec at an opening of not less than 18”.

8. Trial (“Dry”) Runs

Before a new nuclide or procedure is introduced, it is accepted practice to rehearse the operations without the radionuclide present. This will help to increase efficiency, identify problem areas, and may reduce the time needed to complete the task.

9. Protective Clothing

At a minimum, a safety glasses or goggles, lab coat and gloves shall be worn whenever the possibility of contamination exists i.e., any time unsealed source material is handled. Potentially contaminated lab coats will not be worn outside of the lab.

a. Eye protection is required for all lab occupants under the

University's Chemical Hygiene Plan, and is additionally important as protection to the lens of the eye from high-energy betas emitted from P-32.

10. Pipetting

Pipetting or similar operations of radioactive solutions by mouth are strictly prohibited.

11. "ALARA" Concept

All exposure to radiation will be kept ALARA (As Low As Reasonably Achievable). Radioisotopes shall be used in such a manner that radiation exposure to personnel and to the environment shall be kept as low as possible. The use of appropriately designed shields and proper work practices will help to minimize exposure. Engineering controls such as fume hoods and glove boxes will help to prevent internal exposure.

12. Remote Handling / Shielding

Whenever possible, remote handling devices such as tongs or forceps should be used when working with significant activities of gamma emitters or high-energy beta emitters. This will increase the distance from the source and thereby reduce the rate of exposure.

a. Do not work over open containers of beta emitters. Lead and/or Plexiglas shields should be used for sources having high radiation intensity. Do not use thin sheet, high-density materials (Pb sheeting) for the shielding of high energy (approaching > 1 MeV) beta radiation.

13. Personnel Monitoring

Personnel monitoring devices such as film badges, Thermoluminescent Dosimeters (TLDs) or other types of personal dosimeters will be utilized based on the type and amount of radioisotopes being used. Film badges or pocket ion chambers cannot detect low energy beta radiation from H-3 and C-14, but will be required for work with higher energy radiations such as P-32 and gamma emitters, which are capable of producing whole body exposure rates > 0.5 mrem/hr.
All personnel who have been designated to wear monitoring equipment by the Radiation Safety Officer shall wear these devices when they work with or near radioactive materials.

14. Monitoring

While working with radioactive materials periodically monitor hands, feet, clothing, and the immediate work area to check for radioactive contamination. Personnel shall monitor themselves and their work surfaces for contamination after each use of unsealed radioactive materials.

15. Removal of Equipment

All equipment that is suspected to have come in contact with unsealed radioactive source material or which has been inside radioactive materials work areas shall be considered potentially contaminated. The equipment must be monitored for contamination by an Authorized User before being removed from the laboratory.

16. Maintenance or Renovation

Whenever maintenance or renovation of potentially contaminated facilities or equipment (sinks, hoods, pumps, lab benches, etc.) is required, a survey of the area will be performed. Radiation Safety Office will perform the survey if other qualified personal are not available.

17. Waste

Radioactive wastes will be placed in specially marked receptacles. Radioactive liquids, other than reinstate from the washing of contaminated glassware, may not be disposed of via the sanitary sewer, unless such disposal was reviewed and approved by the RSC. See “Part Two - Radioactive Waste Disposal” for specific waste handling procedures

18. Animals

The Animal Research Committee and the Radiation Safety Committee must approve isotopic work with animals. See section F of the Part Two of the Radiation Safety and Waste Management Manual for animal/biological waste handling procedures.

a. Animals which have been injected with or that have ingested radionuclides will be handled with the following precautions:

(1) All excreta and animal bedding will be double bagged and treated as radioactive biological waste.
(2) Cages will be monitored for radioactivity and

decontaminated as necessary.

(3) Appropriate warning signs shall be posted on the cages.

(4) Adequate ventilation must be provided when animals are injected with radionuclides, which may be expired and dispersed into a room.

a. Researchers are encouraged to consult the RSO prior to applying for approval to conduct animal research involving the use of radionuclides.

19. Personnel Injuries

All injuries to personnel involving radioactive material, no matter how slight, shall be monitored to determine if the wound is contaminated. Special protection is required to prevent the entry of radioactive materials into the body through wounds. Consult the RSO before handling unsealed source material with an open wound.

NOTE: THE SAFETY OF AN INJURED INDIVIDUAL ALWAYS TAKES PRECEDENCE OVER CONTAMINATION CONTROL. Decontamination efforts are secondary to the provision of first aid and medical attention for the injured individual.

20. Moving Authorized Places of Use

Contact the RSO for approval prior to moving or modifying laboratory or other areas which are authorized for the use or storage of radioactive materials or radiation producing equipment. Notification should be given 30 days in advance to allow time for approval and for performance of termination surveys.

V. INSTRUMENTATION

Radiation detection in radioactive materials areas will usually be accomplished by using some type of gas filled detector, such as a Geiger-Muller (G.M.) detectors or an ion chamber.

A. Types of Radiation Detection Instruments

1. G.M. Detectors

These instruments may be calibrated in mR/hour or in cpm. An end window or pancake probe with a thin detector window will be used (window density thickness of 1 to 2 mg/cm^2). These instruments are approved for the detection of low energy betas (>150 keV) and most gamma radiations.

2. Ion Chambers

An air filled ion chamber will be the preferred instrument to set personnel dose rates and are required for use in high radiation areas.

3. Scintillation Detectors

Hand held scintillation detectors will be used for the detection of low energy gamma emitters such as I-125. This type of detector will normally use a thin NaI(Tl) crystal (approximately 1 mm thick). Typical energies detectable are 10 to 60 keV.

4. Liquid Scintillation Detectors

Liquid scintillation counters will be used for analyzing air samples, smear samples, liquid samples, and samples supporting specific research projects for the presence of low energy β radiations which cannot be detected with hand held detectors (eg., H-3, Fe-55).

B. Instrument Calibration

Portable radiation detection instruments will be calibrated by the Radiation Safety Office, returned to the manufacturer, or sent to a certified vendor for calibration.

Instrumentation calibrated by the Radiation Safety Office will be calibrated in accordance with procedures approved by the S.C. Bureau of Radiological Health.

1. Calibration Frequency

Calibration Frequency shall not exceed 12 months. Instruments which do not display a current calibration sticker (within the last 12 months) are not approved for use.

C. Instrument Use – preoperational checks

Before using any portable detection instrument the following pre-operational instrument checks will be made:

1. Inspect the instrument for signs of physical damage.
2. Verify that the instrument calibration is current, within the last year. Do not use an instrument that is out of calibration.
3. Turn the instrument control knob to the battery check position or depress the battery check button. If batteries are bad or weak,

replace them.

4. If the instrument has a "zero" position on the control knob, move the knob to the zero position and adjust so that the instrument needle reads zero.
5. Response check the instrument by exposing the detector to a known source of ionizing radiation to insure functionality before use.
6. Most hand held instruments have several scales (X0.1, X1, X10, X100). Set the instrument to the highest scale and begin the survey. If no indication is seen, set the instrument to successively lower scales until activity is detected.

VI. RADIATION AND CONTAMINATION SURVEYS

Each user of radioisotopes is responsible for performing surveys of the use area to assure that radioactive sources are adequately shielded and to check for control of radioactive contamination. Survey data will be recorded on a blank "Radiation / Contamination Survey Report" (attachment VI-1) and / or in a radiation safety logbook kept by the users at the authorized place of use.

A. Survey Frequency

1. Each individual user is personally responsible for checking themselves for contamination before leaving radioactive materials areas where unsealed source material has been handled or when leaving areas contaminated above clean area limits.

2. A contamination survey of the immediate work area should be conducted on any day that unsealed source materials are used. This “use survey” ensures that licensed materials have been properly controlled.

3. A formal survey of the entire work area (laboratory) should be conducted at least monthly in any use area where unsealed source material has been used in that month. No survey is required in a month when no radioactive materials work was conducted.

    a. A plan view map of the lab space showing areas of primary use and locations of sample points should be included to document the monthly survey. Contamination surveys will be reported in units of dpm/100 cm^2.

    b. During a periods of non-use of radioactive materials there may be times that no routine contamination surveys are performed. On the first contamination survey subsequent to a period of non-use, please make a note documenting “no use of radioactive materials since previous survey” or works to this affect. This will

help to identify periods where survey data and/or use records should not be available for review or audit.

B. Radiation Surveys

Radiation surveys to verify exposure rates may be required in certain situations. These surveys are performed in order to determine the radiation levels in the vicinity of storage areas, work areas, waste containers, and in adjacent unrestricted areas.

1. Survey requirements

a. These Radiation surveys will be made on a periodic basis in areas where gamma emitting or high-energy beta (>1.0 MeV.) emitting isotopes are used or stored in sufficient quantities to produce whole body exposure rates of ≥ 2 mrem/hour.

b. Radiation surveys will be conducted with a hand held survey meter that is calibrated in units of mR/hr or mrem/hr.

c. Exposure rates will be documented on the monthly survey form.

2. Exposure rate action levels.

a. Dose rates in unrestricted areas will not exceed 2x the background (about 0.05 mR/hr). General area dose rates shall be measured with the detector held at waist level and at a distance of no more than 3 feet from the source.

b. Dose rates in a Radioactive Materials Area will not exceed 2 mR/hr when measured at a distance of no more than 12 inches from the source of exposure or at the posted boundary to a Radiation Area.

C. Contamination Surveys

Contamination surveys by direct survey (frisk) will be conducted with hand held radiation detection instruments calibrated in units of counts per minute (cpm) or mR/hr.

1. Direct Survey (frisk)

Direct monitoring for beta/gamma surface contamination will be by G.M. survey meter equipped with a thin window probe or other instrument capable of detecting radiation emitted by the radioactive material used in the area being surveyed. The area will be surveyed

by slowly moving the instrument probe over the surface in question at a distance of no more than ½ inch and at a rate of no more than 2 inches of travel per second.

a. The instrument should be set on the fast response setting and in the audible mode if the instrument is equipped with a speaker.

b. A direct reading of about 2 times the background reading indicates a contaminated area or item. If contamination is indicated by direct survey, a smear survey will be conducted to determine if the contamination is removable.

c. Survey by direct frisk is not permitted to certify an item or area as "clean" for release to unrestricted areas if the background radiation level is >300 cpm on the meter being used.

2. Smear Surveys

Smear surveys are conducted by thoroughly wiping a surface with a commercially available cloth, or paper disk, or a "Q-tip", and analyzing the sample with an appropriate detection instrument.

a. Surface contamination is reported in units of dpm / 100 cm^2 (4" X 4"). If the surface is large, 100 cm^2 may be approximated by placing the fingertips of the index and middle finger over the disk and, with moderate pressure, drawing an 18" S pattern on the surface. A "q-tip" may be used for objects smaller than 100 cm^2 and the entire surface should be wiped.

b. A field evaluation of a smear sample may be obtained using a hand held G.M. instrument with a pancake or end window probe. Assuming 10% efficiency, a sample with a direct reading of 100 cpm above background has an activity of approximately 1000 dpm.

c. Hand held detection equipment is not sensitive enough to accurately detect smear sample activities below the 200dpm/100cm^2 unrestricted area limit. A laboratory counters, such as a liquid scintillation counter is required for accurately analyzing smear samples to the 200 dpm/100cm^2 removable contamination limit.

d. If H-3 or any other non-detectable by a handheld survey meter isotope is the contaminant of interest, the smear sample must be analyzed in a liquid scintillation counter or in a gas-flow proportional counter.

D. Source Inventory and Leak Test Surveys

1. Inventory

Each RI shall conduct a physical inventory at intervals not to exceed six (6) months to account for all radioactive material received and possessed under that particular RSC approval. Usually, these inventories are performed during regular semiannual project inspections. Records of source inventory and leak checks will be maintained for inspection by the BRH. These records shall include:

a. The quantities and kinds of radioactive material
b. Location of all radioactive material
c. Date the inventory was conducted, and
d. Name of the individual conducting the inventory.

2. Sealed Source Leak Check Criteria

a. Any beta and/or gamma emitting sealed source with an activity ≥ 100 µCi of radioactive material, other than H-3, with a half-life greater than thirty days and in any form other than gas shall be tested for leakage at intervals not to exceed six months.

b. Alpha emitting sealed sources with an activity of ≥ 10 µCi will be leak checked at intervals not to exceed three months.

c. All newly obtained sealed sources will be tested for leakage prior to being put into service.

d. If a source has not been removed from the storage location or container since the last leak check, only a physical inventory will be performed. No leak check will be required until the next time the source is removed from its storage container or location.

3. Leak Test Procedure

a. Source leak test will be conducted in accordance with Radiation Protection RSOP-007 *Sealed Source Leak Test.* Survey data will be recorded on "Sealed Source Inventory and Leak Check form" (see attachment VI-2) and entered into the Database.

b. If the test reveals the presence of 0.005 microcuries or more of removable contamination, the source will immediately be withdrawn from use and shall be decontaminated, repaired, or disposed of in accordance with BRH regulations.

c. Note: Sealed sources will not be included for disposal in normal dry radioactive waste. Special approval must be obtained from the disposal site and the BRH for disposal of sealed sources.

VII. TRANSFER OF RADIOACTIVE SOURCE MATERIAL

A. Documentation of Transfer

Title A regulations require that an official record be maintained for each transfer of radioactive source material between licensees.

1. As the original holder of the source material to be transferred, the University will verify that the prospective recipient of the transfer is licensed by an “Agreement State” or by the U.S. Nuclear Regulatory Commission to possess the specific nuclide and in the quantity and physical form in question.

B. Sharing of Source Materials

University policy requires that Responsible Investigators maintain a record for each transfer of source material between users. Several investigators may wish to share quantities of source material as a matter of convenience or as a cost cutting measure. The transfer will be documented on the Form R-016 “Radioactive Material Transfer Report” (see attachment VII-1).

A "Rad Material Transfer Form" will be completed for each aliquot of source material being transferred. The signed original of the form will be retained by the RSO and a copy provided to each RI who receives the transferred source material.

The transfer form will list the following:

- Original shipment number;
- The total activity of the nuclide transferred;
- Name and / or authorization number (or License number for an entity outside of the Clemson University) of the other party to the transfer;
- The date the transfer took place;
- Packaging information, if applicable.

VIII. CONTAMINATION LIMITS AND CONTAMINATION CONTROL

Restricted area is any area to which access is controlled for the purposes of protection of individuals from exposure to radiation and radioactive materials.

Before removing any piece of equipment from a restricted area where unsealed source material is used, a contamination survey will be performed on the

equipment. Unrestricted area limits will be met for unconditional release of items or equipment from a Restricted Area, such as, a laboratory which is designated as a Radioactive Materials Area.

1. Unrestricted Area Limits

Type of contamination	Beta/Gamma	Alpha
Removable	<200 dpm/100 cm^2	<20 dpm/100 cm^2
Non-removable	<100 cpm above bkg. or <.05 mR/hr	N/A

2. Measurement of non-removable (fixed) contamination should be taken with a G-M instrument calibrated in cpm or in mR/hr equipped with a thin end window or pancake probe. Direct readings of >100 cpm above bkg. or >.05 mR/hr above area background when measured at near contact with the source (a distance of no more than 1/2") indicate a contaminated article or area.

3. Background in the area where the measurement is made will be no more than 300 cpm.

IX. SPILLS OF RADIOACTIVE MATERIALS

All spills of radioactive material require immediate response. In the event of a spill, initial response rest with the individuals working in the area, involved with, and/or responsible for the spill.

UNDER NO CIRCUMSTANCES SHALL AN UNTRAINED PERSON BE ALLOWED TO EXAMINE OR CLEAN UP A SPILL OF RADIOACTIVE MATERIAL.

If assistance is needed, contact the RSO.

A. Laboratory Contamination

1. Minor spills of radioactive materials over relatively small surface areas may be decontaminated by laboratory personnel.

2. If laboratory contamination is widespread (on workbench, chairs, floor, etc.) or involves multi µCi to mCi levels of activity, the Radiation Safety Officer or his designee will supervise the decontamination activity.

B. Response to Spills

The following general guidelines should be followed when responding to a spill.

1. Inform other laboratory personnel of the spill. Have them leave the area, but remain in one place in order to minimize the possible spread of contamination.

2. Stop and/or confine the spill and restrict access to the contaminated area. If the material is a liquid, place an absorbent material such as paper towels, tissues, cloth, etc. over the spill to prevent its spread. If the material is a powered solid, attempt to contain its spread by gently covering the area with a similar protective barrier preferably wet cloth or wet absorbent paper. Secure any local ventilation equipment that may aid in the transport of the material or cause airborne contamination. Post or cordon off the area and restrict access to those individuals directly involved with the cleanup.

3. Monitor any personnel that were in the area at the time of the spill. Begin with the head giving special attention to the nose and mouth to assess the possibility that internal uptake may have occurred. Any facial contamination will be immediately reported to the RSO. Remove any contaminated clothing and decontaminate as necessary.

4. Decontaminate the area. If the activity of the material is not known prior to the spill, obtain a sample from the spill in order to evaluate the proper decontamination technique to be used. Perform a survey after each decontamination order to assess the effectiveness of the effort.

5. Begin wiping or mopping at the periphery of the spill and work toward the center of the contamination. Any personnel involved in the decontamination effort will wear at a minimum: a lab coat, double vinyl or rubber gloves, and plastic shoe covers. If these items are not available in the lab they may be obtained from the RSO.

6. Place all contaminated items in proper waste containers. Contamination not readily removable after three attempts should be reported to the RSO.

X. TRANSPORTING AND STORAGE

A. Transporting

Radioactive materials should be "doubly-contained" when in transit in order

to help prevent and contain any leakage. Radioactive material will not be left unattended during transport. Notify the RSO any time rad material with a dose rate of 50 mR/hr at 1" from the object is to be moved outside the controlled area.

B. Storage

Radioactive materials will not be left unattended in places where unauthorized persons may handle or remove them. Food and beverages shall not be stored in the same place as radioactive material (e.g., the same refrigerator). Use a plastic box or other secondary container for items in storage.

1. All radioactive material will be stored in such a manner that the dose rates at the posted boundary of the area or 12" from the surface of any container is <2 mR/hr.

   NOTE: Loss or theft of radioactive material must be reported immediately to the Radiation Safety Officer.

XI. PROCUREMENT OF RADIOACTIVE MATERIALS

Radioactive materials may be ordered only by a Responsible Investigator or under his/her approval and only for radionuclides and within the limits of his/her authorization.

Packages containing radioactive materials will be delivered to the one of the following addresses:

Radiation Safety Facility
501 Lake Dr.
Clemson, S.C. 29631

or

Environmental Engineering and Earth Sciences (EEES) Facility
342 Computer Ct.,
Anderson, SC 29625

Also include authorization number and/or RI name.

XII. RECEIPT OF PACKAGES OF RADIOACTIVE MATERIALS

Receipt and surveys of packages containing radioactive materials will be conducted in accordance with RSOP-003 (Attachment XII-1). Packages will be received between the hours of 08:00 and 4:30 Mon-Fri unless prearranged with

the shipper and the Radiation Safety or other personnel authorized to receive radioactive material package.

A. Package Receipt and Survey by the Radioactive Material Project Personnel

1. At a minimum, gloves will be worn when opening packages containing radioactive materials.

2. Visually inspect the package for any signs of physical damage. Substantial damage to the exterior of a package may indicate loss of integrity of the inner container and should be placed inside a fume hood for opening.

3. Remove and review the packing slip to identify the nuclide and total activity contained in the package.

4. If the nuclide is in a gaseous or volatile form, such as I-125 or I-131, open the package inside a fume hood. Tongs or forceps should be used when handling vials containing gamma or high-energy beta emitters (Cs-137, Na-22, P-32, etc.).

5. Perform a radiation survey of the package. If radiation levels are above 2 mR/hr at 12", the package should be placed in a posted radiation area.

6. If the dose rate at 1 m (3.3 ft.) differs significantly from the Transport Index (TI) stated on the package label, immediately notify the RSO.

7. Perform a contamination survey on the exterior of the package.

8. If the removable contamination level on the exterior of the package exceeds 200 dpm/100 cm^2, place the package into the secondary containment to prevent spread of the contamination, placed it in a posted contaminated area and immediately notify the RSO.

9. If the surface dose rate exceeds 200 mrem/hr or if the dose rate at 1 m (3.3 ft.) exceeds 10 mrem/hr, or if the removable contamination levels are found on the package surface in excess of 22,000 dpm/100 cm^2, the campus RSO will immediately notify the final delivery carrier and the SC BRH.

10. Check the integrity of the final source container (usually a lead or plastic container) and perform a contamination survey of its surface. Look for broken seals or vials, loss of liquid, condensation, or discoloration of the packing material that could indicate leakage.

11. Perform a contamination survey of the stock vial and analyze it with a liquid scintillation counter or other currently calibrated radiation detection device with a minimum detectable activity of less than 200 dpm for the nuclide in question.

12. If the contamination levels exceed 200 dpm / 100 cm^2 decontaminate the vial or place it in a plastic bag marked as "contaminated".

13. If the removable contamination level on the stock vial exceeds 50,000 dpm / 100 cm^2 the manufacturer will be contacted to report loss of the material.

14. Carefully monitor the empty package and packing materials before discarding into clean waste. The empty package and packing material must meet the limits for an unrestricted area before being released into clean waste. All labeling or marking denoting radioactive materials must be removed and/or defaced beyond recognition prior to disposal in clean waste.

XIII. LABELING AND POSTING REQUIREMENTS

All areas, items, or containers within Restricted Areas will be posted with appropriate warning signs or labels as defined by S.C. DHEC Title-A Radioactive Materials Regulation 61-63.

1. Restricted Area

   Any area to which access is controlled by the licensee for purposes of protection of individuals from exposure to radiation and rad materials.

2. Radioactive Materials Area

   At a minimum, the entrance doors to rooms and laboratories in which radioactive materials are stored or used will be posted with a yellow and magenta sign bearing the radiation trefoil and the words "CAUTION - RADIOACTIVE MATERIALS".

3. Radiation Area

   A radiation area is any area where there exist dose rates such that a major portion of the body could receive a dose of 5 millirem in any one hour. Dose rates of > 5 mR/hr but <100 mR/hr require posting CAUTION - RADIATION AREA. The dose rate at the boundary of a radiation area may not exceed 5 mR/hr. The posting of equipment as a radiation area will be based on a dose rate of 5 mR/hr measured

at a distance of 12" from the source.

4. High Radiation Area

Any area where there exist dose rates such that a major portion of the body could receive a dose of 100 millirem in any one hour will constitute a HIGH RADIATION AREA. Dose rates of ≥100 mR/hr, but <1000 mR/hr require posting as a DANGER - HIGH RADIATION AREA. The dose rate at the boundary of a high radiation area shall not exceed 100 mR/hr. The posting of equipment as a high radiation area may be based on a reading of 100 mR/hr when measured at a distance of no more than 12".

5. Airborne Radioactivity Area

Any room, enclosure or operating area where airborne radioactivity is in excess of 20% of the amounts specified in S.C. DHEC Title A RHA 3.53 Appendix B, Table 1 Column 3. All such areas require posting CAUTION - AIRBORNE RADIOACTIVITY AREA.

6. Contaminated Area

Any area with removable surface contamination ≥200 dpm/100 cm^2 beta / gamma or 20 dpm / 100 cm^2 alpha

7. Additional Postings

DHEC Form RHA-20, Notice to Employees will be posted in a highly visible location within the lab or use area.

XIV. BASIC PROTECTION MEASURES

Earlier in this manual the "ALARA Concept" was mentioned. This idea that radiation exposure should be kept as low as reasonably achievable is based on a linear extrapolation model. This concept holds that any exposure no matter how small has some negative effect. When attempting to limit personnel exposure to ionizing radiation, controlling the variables of Time, Distance, and Shielding will have the greatest effect.

A. Time

For a source of given strength, the absorbed dose is proportional to the duration of the exposure. Experiments should be carefully planned to minimize exposure time. This is one reason it is a good practice to use trial runs without the radionuclide present to increase your efficiency, identify problem areas, and possibly reduce the time needed to complete a task.

B. Distance

The exposure rate from a point source of radiation is inversely proportional to the square of the distance. In other words, increasing the distance by a factor of 2 will decrease the exposure rate by a factor of 4.

C. Shielding

Shielding is any material that is used to absorb or attenuate radiation before it reaches a point of interest.

1. High energy beta Particles such as those from the decay of P-32 (1.73 MeV maximum energy), will be shielded using low atomic number material such as acrylic sheeting or wood to avoid x-ray production from Bremsstrahlung radiation.

2. Gamma or X-ray shields will be composed of high atomic number materials such as lead, concrete, or water. When more than one layer of shielding is used, the joints of the shielding layers should be overlapped.

3. Neutron shields should be constructed of hydrogenous materials such as water, paraffin, or plastic.

4. Half value / Tenth Value Layer shielding (gamma):

The thickness of shielding material required to reduce the exposure rate to one half or one tenth of its original value respectively. A table of some measured HVL and TVL values for various shield materials is shown below.

	Half value layer		Tenth value layer	
Radiation	**Lead**	**Concrete**	**Lead**	**Concrete**
125 kVp X-ray	0.28 mm	2.0 cm	0.93 mm	6.6 cm
Cs-137	6.5 mm	4.8 cm	21.6 mm	15.7 cm
Co-60	12 mm	6.2 cm	40 mm	20.6 cm

XV. DOSE LIMITS

1. The following are Maximum Permissible Occupational Dose limits both from external radiation and from the radioactive material uptake inside the body:

Applicable area of body	rem per year
Whole body; head and trunk, active blood forming organs, gonads	5 rem (0.05 Sv)
Hands and forearms; feet and ankles (Up to the elbow and/or knee)	50 rem (0.5 Sv)
Skin of whole body	50 rem (0.5 Sv)
Eye dose equivalent	15 rem (0.15 Sv)

2. Exposure of Minors

Occupational exposure to any individual who is under the age of 18 is permitted only if their exposure is limited to less than 10% of the limits specified above. For this reason, minors will not be employed as full-time radiation workers.

3. Pregnant Worker Exposure Limits

The Nuclear Regulatory Commission (NRC) and the State of S.C. require instruction of women radiation workers in the hazards associated with radioactive materials and radiation; and, in the precautions and safety measures to be followed to minimize radiation exposure. The limit for external radiation exposure to pregnant workers is: 500 millirem for the entire gestation period
It is the responsibility of each women working with radioactive materials or with radiation producing equipment to notify in writing both her immediate supervisor and the Radiation Safety Officer as soon as she is aware of her pregnancy.

NOTE: For further information on radiation exposure during pregnancy see the guide at the end of part one of this manual and contact the Radiation Safety Officer.

XVI. PERSONNEL RADIATION MONITORING

Any individual who enters a High Radiation Area or who receives, or is likely to receive a dose in any calendar year in excess of 10% of the applicable values specified in Title-A Radioactive Materials Regulation 61-63, RHA 3.17, will be monitored for occupational external radiation exposure. Personnel monitoring will be provided by a NAVLAP certified vendor.

A. Personnel dosimeters

All personnel dosimeters will be read at least quarterly.

The following practices will be observed when wearing a personnel monitoring device:

1. If an individual has been issued a dosimeter, it will always be worn any time the individual enters a restricted area.
2. Whole body dosimeters should normally be worn on the trunk of the body between the waist and neck preferably in the vicinity of the collar and breast pocket.
3. Extremity monitoring may be required when handling high-energy beta emitters or high dose rates of gamma emitters, or when working with open beam x-ray. A ring dosimeter should be worn on a finger of the hand used to hold the source and so that the active area of the dosimeter faces the source. Rubber gloves will be worn over the dosimeter.
4. Personnel monitoring devices will not be taken home. Dosimeters will be left in a secure area away from the radiation source.
5. Personnel dosimetry will only be worn by the individuals to whom they are officially issued. No personnel monitoring device will be intentionally exposed to ionizing radiation unless it is being worn by the person to whom it was issued for the purpose documenting occupational exposure to radiation.
6. Personnel monitoring devices will not be worn while undergoing medical procedures. The personal dosimeter is for monitoring your occupational exposure - not medical exposure.

B. Self-Reading Dosimeters

Self-reading dosimeters are fountain pen sized ion chambers ("pocket dosimeter") or pager-style electronic devices that directly measure and display exposure to X or gamma radiation. Pocket dosimeters require a separate charging device to set to the zero position. Like charges are placed on a center electrode and a movable quartz fiber. As radiation is incident on the sensitive volume of the dosimeter the charge between the fixed and movable electrode is lost and the movable quartz fiber moves closer to the fixed electrode. This movement may be viewed against an internal scale through a built-in compound microscope. Self-reading dosimeters are available in various scales, the most prevalent being 0 - 200 millirem.

1. Self-reading dosimeters will detect only X and gamma radiation.

2. Self-reading dosimetry will be worn by personnel when entering any area posted as a High Radiation Area.

3. Self-reading dosimeters will be calibrated at least annually by the NVLAP accredited provider.

C. Internal Monitoring - Bioassays

Bioassays shall be performed for all persons who may be exposed to radioactive materials in such a manner that an internal uptake is likely to exceed 0.1 ALI.

1. Routine Measurements

a. Baseline measurements. An individual's baseline measurement of radioactive material within the body will be conducted prior to initial work activities that involve exposure to radioactive materials, for which monitoring is required

b. Periodic measurements. The frequency of periodic measurements shall be based on the worker's access, work practices, measured levels of airborne radioactive material, and exposure time. Periodic measurements will be made when the cumulative exposure to airborne radioactivity, since the most recent bioassay measurement, is > 0.02 ALI (40 DAC hours).

c. Termination measurements. When an individual is no longer subject to the bioassay program, because of termination of employment or change in employment status.

2. Internal Uptake

A bioassay will also be initiated anytime an internal uptake of radioactive material is suspected to have occurred, for instance, when facial and/or nasal contamination is found.

4. Special Monitoring

Situations such as a failed respiratory protective device, inadequate engineering controls, inadvertent ingestion, contamination of a wound, or skin absorption shall be evaluated on a case-by-case basis. Circumstances that should be considered when determining whether potential uptakes should be evaluated include:

a. The presence of unusually high levels of facial and/or nasal contamination,

b. Entry into airborne radioactivity areas without appropriate exposure controls,

c. Operational events with a reasonable likelihood that a worker was exposed to unknown quantities of airborne radioactive material (e.g., loss of system or container integrity),

d. Known or suspected incidents of a worker ingesting radioactive material,

e. Incidents that result in contamination of wounds or other skin absorptions,

f. Evidence of damage to or failure of a respiratory protective device.

4. Evaluation Level

If initial bioassay measurements indicate that an intake is greater than an evaluation level of 0.02 ALI, additional available data, such as airborne measurements or additional bioassay measurements, will be used to obtain the best estimate of actual intake.

5. Investigation Level

For single intakes that are greater than 10% of the ALI, a thorough investigation of the exposure shall be made. If an internal uptake exceeds an investigation level of 0.1 ALI, multiple bioassay measurements and an evaluation of available workplace monitoring data will be conducted. In this case, daily measurements will be made until a pattern of bodily retention and excretion can be established.

a. For uptakes exceeding the ALI's, the bioassay data evaluations shall consider additional data on the physical and chemical characteristics and the exposed individual's physical and biokinetic processes.

6. Sampling

Bioassays will be performed by obtaining a urine sample from the exposed individual, mixing one ml. of the sample urine with 10 ml. of a commercially available scintillation cocktail, and analyzing the sample with a liquid scintillation counter.

7. Thyroid Scan

Bioassays for radioiodine (I-125, I-131) shall be performed for

individuals working with quantities listed below:

Types of Operation	Volatile* or dispersible form	Bound to non-volatile agent
Processes in open room or bench with possible escape of iodine from process vessels	1.0 mCi	10 mCi
Processes with possible escape of iodine carried out within a fume hood of adequate design, face velocity and performance reliability	10 mCi	100 mCi
Processes carried out within boxes, ordinarily closed, but with possible release of iodine from process and occasional exposure to contaminated box and box leakage	100 mCi	1000 mCi

Bioassay for radioiodine will be performed by a thyroid count utilizing a NaI(Tl) scintillation or analogous detector, designed for the detection of low energy (10-60 keV) gamma photons. The detector will be placed in contact with the neck, over the thyroid of the individual under consideration, and conducting a 10-minute count.

a. The instrument used to conduct the thyroid count must be calibrated with NIST traceable source(-s) placed within a plastic neck phantom which approximates the physical characteristics and geometry of the thyroid of reference man.

XVII. FACILITIES

A. Work Areas

Portions of the laboratory should be designated as radioactive material work areas. Keep these areas isolated from other non-radioactive areas in order to reduce the likelihood of the spread of contamination. The radioactive material work areas should be clearly labeled and unauthorized personnel should be restricted from these areas when radioactive material is present or when contamination is possible. Yellow and magenta rope, ribbon or tape and appropriate warning signs may be used for this purpose.

B. Storage

All radioactive material under the control of an RI shall be stored in a secure, lockable storage area. If more than one user shares a common facility, all radioactive material belonging to each RI shall be segregated in such a way

that accidental transfer of material is unlikely.

C. Fume Hoods

A fume hood is necessary when working with volatile radionuclides (ex., radioiodine) or when heating or stirring solutions containing radioactive materials. All work should be performed in a hood that has a face velocity of 100±20 ft/min measured at a working sash height of 18".

Desirable characteristic of radioactive material fume hoods:

1. The interior should be one-piece, seamless material, with covered corners free of joints, cracks or gaskets. The preferred material is stainless steel.

2. Ducts should be of stainless steel. Each hood should be ducted independently directly to the roof.

3. Blowers should be roof-mounted, spark-proof, explosion-proof units.

4. A HEPA filter should be used in the exhaust duct if the unit is to be heavily used for radioisotope work.

5. New units should have an air motion sensor and alarm to ensure proper air velocity and direction. Older units should have, at a minimum, a signal light to show that the motor is receiving power.

6. When possible locate hoods in areas that would not have to be passed in order to exit in case of an emergency. As much as possible, locate hoods in a draft-free, low-traffic area. If ceiling mounted vent ducts terminate directly over a fume hood, provisions should be made to deflect the incoming air away from the fume hood opening.

XVIII. DECONTAMINATION

A. Area Decontamination Action Levels

1. If laboratory contamination is localized (e.g. small portion of a workbench or floor) and exceeds unrestricted area limits (VII.A.1) then the area will be immediately decontaminated and/or posted as contaminated.

2. If laboratory contamination is widespread, (e.g. on workbench, chairs, floor, refrigerator etc.) or if removable contamination in any area exceeds 1,000 dpm/100 cm^2 alpha or 50,000 dpm/100 cm^2

beta/gamma, it should be reported to the RSO.

B. Personnel Decontamination

1. Skin Contamination, even in small amounts, should be treated seriously. External contamination results in local skin exposure. Radionuclides may penetrate intact skin, especially when organic solvents are present. Contamination may be ingested or inhaled and may be spread to other areas or personnel. Therefore, it is most critical to remove loose contamination as quickly and safely as possible. In general, except for decontamination of hands, all procedures should be supervised by the RSO or his/her designee.

   The following procedures should be used to decontaminate the skin:

   a. Prior to commencing personnel decontamination carefully monitor the contaminated area to establish the level of contamination. This is important so that dose to the contaminated area can be calculated.
   b. Wet contaminated area and apply mild soap; use warm -- not hot water.
   c. Work up a good lather and use a soft bristled brush, if necessary. Clean the area as you would normally.
   d. Dry and monitor between washes.
   e. If contamination levels are still detectable after three washings, notify radiation safety personnel.

2. Hair decontamination:

   a. Shampoo hair in the normal manner with the head deflected to the side or backwards
   b. Rinse well with warm water, towel dry and monitor for contamination. If no activity is detectable, allow the hair to completely dry and resurvey by direct frisk.
   c. Even small amounts of water can mask detection of beta contamination.

3. If eyes are contaminated:

   a. Contact the RSO.
   b. Spread eyelids and rinse gently with water in a direction from the nose to edge of the face.

4. If the whole body contamination exists notify the RSO.

   Personnel with whole body contamination will be dressed in full body

disposable coveralls and transported to the Radiation Safety Facility for decontamination in a personnel decontamination shower.

a. Remove all clothing and bag.
b. Shower immediately with water; brush with mild soap.
c. Repeat at least twice.
d. Towel dry and perform a whole body frisk.

5. Contaminated wounds

Any wound acquired in the presence of loose surface contamination or while working with unsealed radionuclides should be considered contaminated until proven otherwise. The following procedures should be instituted.

a. Notify the campus RSO immediately.
b. Rinse the wound under running water.
c. Delimit contaminated area with waterproof material.
d. Decontaminate the skin around wound.
e. Remove wound cover and apply sterile dressing
f. If highly radiotoxic substances are involved, a venous tourniquet may be applied close to the wound.

6. If facial contamination occurs or if internal contamination is suspected, the following action should be taken.

a. Notify the R.S.O.
b. Determine the time of accident, the type of uptake (ingestion, inhalation, absorption), the radionuclide involved, and the chemical nature and level of activity of the contaminant if possible

XIX. INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

This material is taken directly from the US Nuclear Regulatory Guide 8.13 "Instruction Concerning Prenatal Radiation Exposure". It provides instructions about the health protection problems associated with prenatal radiation exposure. It is intended for female employees working in or frequenting any area where radioactive material or radiation producing equipment is used. Anyone who supervises employees who work with radioactive materials or radiation producing equipment will likewise be familiar with this guideline.

After reading the information below, please complete and return the attached Form R-005 *Voluntary Notification of Declared Pregnancy* to:

Konstantin Povod
Radiation Safety Office
391 College Ave., Suite 104
kpovod@clemson.edu

Contact the RSO for questions concerning this material.

A. Possible Health Risks to Children of Women Exposed to Radiation during Pregnancy

During pregnancy, you should be aware of things in your surroundings or in your style of life that could affect your unborn child. For those of you who work in or visit areas designated as Restricted Areas (where access is controlled to protect individuals from being exposed to radiation and radioactive materials), it is desirable that you understand the biological risks of radiation to your unborn child.

1. Background Radiation

Everyone is exposed daily to various kinds of radiation: heat, light, ultraviolet, microwave, ionizing, and so on. For the purposes of this guide, only ionizing radiation (such as x-rays, gamma rays, neutrons, and other high-speed atomic particles) is considered. Actually, everything is radioactive and all human activities involve exposure to radiation. People are exposed to different amounts of natural "background" ionizing radiation depending on where they live. Radon gas in homes is a problem of growing concern. Background radiation comes from three sources:

Background Radiation	Average Annual Dose
Terrestrial radiation	30 mrem
Cosmic radiation	35 mrem
Radon	200 mrem
Radioactivity normally found within the human body	30 mrem

The first two of these sources expose the body from the outside, and the last two expose it from the inside. The average person receives a total dose of about 300 mrem per year from the natural background radiation.

2. Medical Procedures

In addition to exposure from normal background radiation, medical procedures may contribute to the dose people receive. The following table lists the average doses from different medical applications.

X-ray Procedure	Average Dose
Normal dental examination	< 10 mrem
Normal chest examination	10-20 mrem
Mammogram	30-60 mrem
Barium enema examination	300-600 mrem
Chest or abdomen CT	500-700 mrem
Abdomen and pelvis CT	800-1100 mrem

3. NRC Position

NRC regulations and guidance are based on the conservative assumption that any amount of radiation, no matter how small, can have a harmful effect on an adult, child, or unborn child. This assumption is said to be conservative because there are no data showing ill effects from small doses; the National Academy of Sciences recently expressed "uncertainty as to whether a dose of, say, 1 rad would have any effect at all." Although it is known that the

unborn child is more sensitive to radiation than adults, particularly during certain stages of development, the NRC has not established a special dose limit for protection of the unborn child. Such a limit could result in job discrimination for women of child-bearing age and perhaps in the invasion of privacy (if pregnancy tests were required) if a separate regulatory dose limit were specified for the unborn child. Therefore, the NRC has taken the position that special protection of the unborn child should be voluntary and should be based on decisions made by workers and employers who are well informed about the risks involved.

a. For the NRC position to be effective, it is important that both the employee and the employer understand the risk to the unborn child from radiation received as a result of the occupational exposure of the mother. This document tries to explain the risk as clearly as possible and to compare it with other risks to the unborn child during pregnancy. It is hoped this will help pregnant employees balance the risk to the unborn child against the benefits of employment to decide if the risk is worth taking. This document also discusses methods of keeping the dose, and therefore the risk, to the unborn child as low as is reasonable achievable.

4. Radiation Dose Limits

The NRC's present limit on the radiation dose that can be received on the job is 1,250 millirems per quarter (3 months). Working minors (those under 18) are limited to a dose equal to one-tenth that of adults, 125 millirems per quarter. (See § 20.101 of 10 CFR Part 20.)

a. Because of the sensitivity of the unborn child, the National Council on Radiation Protection and Measurements (NCRP) has recommended that the dose equivalent to the unborn child from occupational exposure of the expectant mother be limited to 500 millirems for the entire pregnancy (Ref.2). The 1987 Presidential guidance (Ref. 1) specifies an effective dose equivalent limit of 500 millirems to the unborn child if the pregnancy has been declared by the mother; the guidance also recommends that substantial variations in the rate of exposure be avoided. The NRC (in § 20.208 of its proposed revision to Part 20) has proposed adoption of the above limits on dose and rate of exposure.

5. Advice for Employee and Employer

Although the risks to the unborn child are small under normal working conditions, it is still advisable to limit the radiation dose from occupational exposure to no more than 500 millirems for the total pregnancy. Employee and employer should work together to decide the best method for accomplishing this goal. Some methods that might be used include reducing the time spent in radiation areas, wearing some shielding over the abdominal area, and keeping and extra distance from radiation sources when possible. The employer or health physicist will be able to estimate the probable dose to the unborn child during the normal nine-month pregnancy period and to inform the employee of the amount. If the predicted dose exceeds 500 millirems, the employee and employer should work out schedules or procedures to limit the dose to the 500 millirem recommended limit.

a. It is important that the employee inform the employer of her condition as soon as she realizes she is pregnant if the dose to the unborn child is to be minimized.

6. Internal Hazards

This document has been directed primarily toward a discussion of radiation doses received from sources outside the body. Workers should also be aware that there is a risk of radioactive material entering the body in workplaces where unsealed radioactive material is used. Nuclear medicine clinics, laboratories, and certain manufacturers use radioactive material in bulk form, often as a liquid or a gas. A list of the commonly used materials and safety precautions for each is beyond the scope of this document, but certain general precautions might include the following:

a. Do not smoke, eat, drink, or apply cosmetics around radioactive material.

b. Do not pipette solutions by mouth.

c. Use disposable gloves while handling radioactive material when feasible.

d. Wash hands after working around radioactive material.

c. Wear lab coats or other protective clothing whenever there is a possibility of spills.

Remember that the employer is required to have demonstrated that it will have safe procedures and practices before the NRC issues it a license to

use radioactive material. Workers are urged to follow established procedures and consult the employer's radiation safety officer or health physicist whenever problems or questions arise.

B. Effect on the Embryo / Fetus of Exposure to Radiation and Other Environmental Hazards

In order to decide whether to continue working while exposed to ionizing radiation during her pregnancy, a woman should understand the potential effects on an embryo/fetus, including those that may be produced by various environmental risks such as smoking and drinking. This will allow her to compare these risks with those produced by exposure to ionizing radiation.

1. Radiation Risk

Table 1 provides information on the potential effects resulting from exposure of an embryo/fetus to radiation and non-radiation risks. The second column gives the rate at which the effect is produced by natural causes in terms of the number per thousand cases. The fourth column gives the number of additional effects per thousand cases believed to be produced by exposure to the specified amount of the risk factor.

The following section discusses the studies from which the information in Table 1 was derived. The results of exposure of the embryo/fetus to the risk factors and the dependence on the amount of exposure are explained.

a. Childhood Cancer

Numerous studies of radiation-induced childhood cancer have been performed, but a number of them are controversial. The National Academy of Science (NAS) BEIR report reevaluated the data from these studies and even reanalyzed the results. Some of the strongest support for a causal relationship is provided by twin data from the Oxford survey (Ref. 4). For maternal radiation doses of 1,000 millirems, the excess number of deaths (above those occurring from natural causes) was found to be 0.6 deaths per thousand children (Ref. 4).

b. Mental Retardation and Abnormal Smallness of the Head (Microcephaly)

Studies of Japanese children who were exposed while in the

womb to the atomic bomb radiation at Hiroshima and Nagasaki have shown evidence of both small head size and mental retardation. Most of the children were exposed to radiation doses in the range of 1 to 50 rads. The importance of the most recent study lies in the fact that investigators were able to show that the gestational age (age of the embryo/fetus after conception) at the time the children were exposed was a critical factor (Ref. 7). The approximate risk of small head size as a function of gestational age is shown in Table 1. For a radiation dose of 1,000 millirems at 4 to 7 weeks after conception, the excess cases of small head size were 5 per thousand; and 8 to 11 weeks, it was 9 per thousand (Ref. 7).

(1) In another study, the highest risk of mental retardation occurred during the 8 to 15-week period after conception (Ref. 8). A recent EPA study (Ref. 16) has calculated that excess cases of mental retardation per live birth lie between 0.5 and 4 per thousand per rad.

c. Genetic Effects

Radiation-induced genetic effects have not been observed to date in humans. The largest source of material for genetic studies involves the survivors of Hiroshima and Nagasaki, but the 77,000 births that occurred among the survivors showed no evidence of genetic effects. For doses received by the pregnant worker in the course of employment considered in this guide, the dose received by the embryo/fetus apparently would have negligible effect on descendants (Refs. 17 and 18).

2. Non-radiation Risks

a. Occupation

A recent study (Ref. 9) involving the birth records of 130,000 children in the State of Washington indicates that the risk of death to the unborn child is related to the occupation of the mother. Workers in the metal industry, the chemical industry, medical technology, the wood industry, the textile industry, and farms exhibited stillbirths or spontaneous abortions at a rate of 90 per thousand above that of workers in the control group, which consisted of workers in several other industries.

b. Alcohol

It has been recognized since ancient times that alcohol consumption had an effect on the unborn child. Carthaginian law forbade the consumption of wine on the wedding night so that a defective child might not be conceived. Recent studies have indicated that small amounts of alcohol consumption have only the minor effect of reducing the birth weight slightly, but when consumption increases to 2 to 4 drinks per day, a pattern of abnormalities called the fetal alcohol syndrome (FAS) begins to appear (Ref. 11). This syndrome consists of reduced growth in the unborn child, faulty brain function, and abnormal facial features. There is a syndrome that has the same symptoms as full-blown FAS that occurs in children born to mothers who have not consumed alcohol. This naturally occurring syndrome occurs in about 1 to 2 cases per thousand (Ref. 10).

(1) For mothers who consume 2 to 4 drinks per day, the excess occurrences number about 100 per thousand; and for those who consume more than 4 drinks per day, excess occurrences number 200 per thousand. The most sensitive period for this effect of alcohol appears to be the first few weeks after conception, before the mother-to-be realizes she is pregnant (Refs. 10 and 11). Also, 17% or 170 per thousand of the embryo/fetuses of chronic alcoholics develop FAS and die before birth (Ref. 15). FAS was first identified in 1973 in the United States where less than full-blown effects of the syndrome are now referred to as fetal alcohol effects (FAE) (Ref. 12).

c. Smoking

Smoking during pregnancy causes reduced birth weights in babies amounting to 5 to 9 ounces on the average. In addition, there is an increased risk of 5 infant deaths per thousand for mothers who smoke less than one pack per day and 10 infant deaths per thousand for mothers who smoke one or more packs per day (Ref. 13).

d. Miscellaneous

Numerous other risks affect the embryo/fetus, only a few of which are touched upon here. Most people are familiar with the drug thalidomide (a sedative given to some pregnant women), which causes children to be born with missing limbs, and the more recent use of the drug diethylstilbestrol (DES),

a synthetic estrogen given to some women to treat menstrual disorders, which produced vaginal cancers in the daughters born to women who took the drug. Living at high altitudes also gives rise to an increase in the number of low-birth-weight children born, while an increase in Down's Syndrome (mongolism) occurs in children born to mothers who are over 35 years of age. The rapid growth in the use of ultrasound in recent years has sparked an ongoing investigation into the risks of using ultrasound for diagnostic procedures (Ref. 19).

Form R-005 **VOLUNTARY NOTIFICATION OF DECLARED PREGNANCY**

PLEASE READ BEFORE COMPLETING THIS FORM: The South Carolina's Department of Health and Environmental Control has established a dose limit of 500 millirems (5 millisieverts) for the embryo/fetus of any radiation worker who voluntarily declares her pregnancy to her employer in writing. The regulations also specify that the dose must be distributed uniformly during the entire period of pregnancy, i.e., the dose the dose received by the embryo/fetus should not exceed about 50 millirems per month. The dose limit for a woman who does not declare her pregnancy is 5,000 millirems (50 millisieverts) per year to the whole body with no provisions made for the dose to the unborn child.

To declare your pregnancy, complete this form and submit it to the Radiation Safety Officer. Confidentiality will be maintained. Once the monitoring begins, a monthly report will be sent directly to you indicating the dose received, if any. We will provide a copy of NRC Regulatory Guide 8.13, *Instruction Concerning Prenatal Exposure* for your information. If you have any questions, please contact the Clemson Radiation Safety Officer.

Name _____
First MI Last

Clemson ID C_____ email_____@clemson.edu

Estimated Date of Conception _____ Estimated Date of Full Term _____

Department/Unit_____ Address _____ Phone _____
Room Building

Do you currently wear a film badge? ☐Yes ☐No

Signature _____ **Date** _____

Submit this form to: **Radiation Safety Officer**
391 College Ave., Suite 104
Clemson, SC 29631

Please do not write below this line, for Radiation Safety Section use only

☐ NRC Regulatory Guide 8.13 issued Monitoring Method: ☐1 badge ☐2 badges

Participant No. _____ Badge No. _____ Series Code _____ Entered By _____ Date _____

Radiation Safety Officer Review _____ Date _____

PART TWO - RADIOACTIVE WASTE DISPOSAL

XX. POLICY AND PURPOSE

This policy is designed to ensure that all radioactive wastes generated under the university's radioactive materials license(s) are properly accounted for and safely handled. Implementation of these practices and procedures will promote the University's compliance with applicable state and federal regulations governing the processing, packaging, storage and disposal of radioactive waste.

XXI. GENERAL RULES AND POLICIES

A. Responsibilities

The Responsible Investigator will assure that each individual user under his/her supervision is informed in the proper practices and procedures for the handling and packaging of radioactive waste. The use of radioactive materials, the handling, packaging, storage and the ultimate disposal of radioactive wastes is strictly regulated by SC DHEC and the US NRC.

1. It is necessary for laboratory personnel to segregate radioactive waste into appropriate categories, and additionally it is important that some types of waste not be inter-mixed. Failure to properly package the waste could lead to spills, unnecessary exposure, fines for regulatory infractions, and in a worst case, to an embargo of waste shipments from Clemson University.

B. Waste minimization

The disposal of radioactive waste at a commercial burial facility is very expensive. Work involving radioactive materials should be pre-planned and practiced in order to minimize the volume of waste generated. Care must be exercised to separate radioactive waste from non-radioactive waste as it is generated.

XXII. WASTE CATEGORIES

The following categories of radioactive wastes are generated as a byproduct of research conducted at the University.

A. Primary Categories

1. Short Half-Life Waste - containing isotopes with a radiological half-life of equal or less than 65 days.

2. Long Half-Life Waste - containing isotopes with a radiological half-life of greater than 65 days.

B. Waste Classification

Radioactive waste is further divided into classifications dependent on its physical/chemical properties.

1. Dry Radioactive Waste - Radioactively contaminated lab trash such as glassware, paper, lab clothing, gloves, culture dishes, syringes, etc. (no free standing liquids).

2. Liquid Waste - Aqueous or organic waste solutions containing radioactive materials or plant tissue to include: carcasses, excreta, organs, blood, or tissue samples.

3. Mixed Waste - Radioactive waste, which also contains hazardous materials / chemicals.

4. Sealed Sources - encapsulated radioactive sources used for instrument response checks or in research applications.

C. Radioactive Waste Containers

1. Containers for all types of radioactive waste may be obtained from the Radiation Safety Office.

2. Each container of waste shall bear a "Rad Tag" or sign with the radiation symbol and the words "Caution - Radioactive Material" or "Radioactive Waste".

3. Separate waste containers will be used for short half-life and long half-life wastes. This will help to reduce the University's waste disposal costs, since the short half-life wastes will be held for decay for at least 10 half-lives and then surveyed and disposed of as "clean", non-radioactive waste.

4. Radioactive wastes may be stored only in restricted areas where it can be secured against unauthorized removal. Storage areas must be listed as an authorized place of use on the Responsible Investigator's Radioactive Materials authorization and must be posted in accordance with University posting procedures. Radioactive waste containers may not be left unattended in a corridor.

5. Radioactive waste containers should be removed from the lab as

soon as they are 3/4 full. Waste container and area dose rates should be checked periodically. Position waste containers in an area such that exposure to personnel is minimized.

a. If the dose rate from a waste container is greater than 2 mR/hr at 12 inches or causes the general area (measured at 3 feet) dose rate to exceed 0.5 mR/hr call the RSO for a waste pickup. If the container dose rate exceeds 2 mR/hr at 12 inches it must be located in a posted Radiation Area.

6. Liquid waste containers are subject to breakage or leakage and should be stored so that if accidental breakage or leakage should occur, the contents will be contained in a small area, e.g., by setting it in a large pan. Liquid containers shall have positive-fitting caps, and must be kept closed.

XXIII. SPECIFIC DISPOSAL PROCEDURES

Radiation Safety personnel will remove radioactive waste from the laboratories. The transfer of the waste from the authorized user to the Radiation Safety Office will be documented on a "radioactive waste disposal form" (see attachment XXIII-1). Waste pickup should be requested on-line at

http://www.clemson.edu/research/safety/forms/rad-pickup.html.

A. Dry Radioactive Waste (DRW)

1. This waste classification is made up of normal laboratory waste, such as, paper, plastic, absorbent coverings, towels, empty test tubes and syringes, culture dishes and other glassware. DRW may contain no freestanding liquids.

2. Items Prohibited in DRW

   a. Liquid in vials, syringes, etc.
   b. Hazardous/infectious/reactive materials
   c. Biological tissues or products in quantities sufficient to produce an odor problem
   d. Sealed/encapsulated radioactive sources
   e. Contaminated lead containers
   f. Sharps (needles, glass pipettes, razor blades, scalpels, etc.). Contaminated sharps must be collected in an appropriate sharps container labelled “Caution – Radioactive Material”.

3. Packaging

a. Dry radioactive wastes will be placed in standardized radioactive labeled waste cans that are lined with thick poly bags. Waste cans, bags, and labels are obtained from the Radiation Safety Office. The use of office-style waste cans is specifically prohibited.

b. Syringes, needles, and pipettes should be placed in separate puncture proof containers before being placed in the waste can. This will prevent puncture of the plastic bag and minimize the possibility of injury to personnel handling the waste.

(1) Broken glassware should be wrapped in heavy paper or cardboard and taped before being discharged into waste cans.

c. Do not over-fill the bag. Leave sufficient room so that the bag top can be twisted and sealed with duct tape. Double bagging when the waste is picked up may be necessary to insure package integrity.

B. Liquid Scintillation Waste

1. In all respects the generator of the waste shall handle all waste liquids containing any radioactive isotope(s) in any concentrations as fully regulated in the sense that all waste liquids shall be stored and labeled as radioactive material or waste.

2. Liquid scintillation fluid waste identified as “biodegradable”, “environmental safe”, “high flash-point” or equivalent will be disposed of as an aqueous waste (see paragraph C below).

3. All liquid radioactive waste that is organic solvent based (“flammable”, “low flash point”) will be handled and disposed of as "mixed waste" (waste that is considered both hazardous and radioactive). Please contact the RSO prior to initiating work that may produce waste in this category.

4. De-regulated Scintillation Fluid/Vials

Liquid scintillation fluid and/or vials that have contained scintillation fluid with an activity of < 0.05 μCi/ml of C-14 and/or H-3 are considered deregulated. This classification applies only to the isotopes C-14 and/or H-3.

a. In order to reduce disposal costs, keep regulated and

deregulated classes of liquid scintillation waste separated. If you have any questions concerning the disposal of scintillation fluid or mixed waste, please call the Radiation Safety Officer before initiating the use of these compounds.

5. Packaging

a. Liquid scintillation vials containing organic solvents may not be emptied into the sewer.

b. Used liquid scintillation vials should be emptied into a properly labelled radioactive liquid waste container. Empty vials will be disposed of as a DRW.

C. Aqueous Waste

1. The University is authorized by SC DHEC to dispose of a limited quantity of radioactive material in aqueous solution by discharge into the University's sanitary sewer system. Only aqueous based solutions, such as biodegradable scintillation fluids, may be discharged into the sanitary sewer system. All waste disposed of by release into the sewer system will be readily soluble in water and meet all of the requirements of SC DHEC Title A Regulation 61-63 RHA 3.29.

2. Radioactive material project personnel may dispose of liquid radioactive waste by the release into the sanitary sewer system only if this project has not been authorized to do so by the Radiation Safety Committee and only within set sewer disposal limits. Other than washing of glassware, waste liquids will be presented to radiation safety personnel for disposal.

3. Project authorized to dispose aqueous radioactive waste into the sanitary sewer must designate a "Radioactive Waste Sink". Do not use a sink for disposal of radioactive waste or for decontamination of laboratory apparatus unless it is so designated.

4. Records of sewer disposal must be maintained. These records should be submitted monthly for review by the Radiation Safety Officer.

5. If for any reason aqueous waste cannot be dumped into a designated drain at the authorized place of use, the waste will be transported to the Radiation Safety Facility and will be dumped into the facility’s sump. This designated sump drains to the sewage treatment’s 161,000-gallon main receiver tank, where raw sewage is first

introduced into the treatment process. Daily dilution flow is approximately 850,000 gal/day.

6. If aqueous waste is transferred to the Radioactive Waste Facility, the liquid waste will be tracked and documented on the Radioactive Waste Disposal Form.

D. Bulk Liquids

Small containers with more than 50 ml of liquid and uncapped or loosely capped containers (e.g., test tubes with Parafilm covers or corks) must be decanted into a bulk liquid container.

1. Bulk Packaging

a. Nalgene carboys are provided by the Radiation Safety Office for collection of waste bulk liquids. These containers are compatible with most organic solvents.

b. The container must be sealed tightly with a cap designed for the container (Parafilm may not be used for this purpose).

E. Biological Waste

This includes carcasses, excreta, organs, blood and bloody rags, and tissue samples in amounts sufficient to produce an odor problem.

1. Packaging

Radioactive waste containing infectious agents shall not be released from the laboratory unless the waste has been autoclaved or otherwise disinfected. Do not initiate the production of biological waste until you have discussed your procedure with the RSO and received approval from the RSC.

a. Disinfected radioactive biological waste will be placed in a heavy yellow radioactive waste bags making sure that the bag is not punctured. Liquid must not be able to leak out. The waste will be double bagged and absorbent will be used as necessary.

b. Blood should be packaged in a strong plastic container. Thin plastic containers such as empty milk jugs are not adequate for this purpose.

c. Animal carcasses containing long-lived nuclides and/or

concentrations of H-3 or C-14 greater than 0.05 μCi/ml will be packaged in double walled metal drums. The inner drum will be double lined with thick poly bags. The animal will be packaged with a combination of lime and absorbent.

d. Animal carcasses with concentrations of < 0.05 μCi / gram of H-3 and/or C-14 may be disposed of without regard to radioactivity. The activity of the waste and its final disposition will be coordinated and documented by the Radiation Safety Office.

2. Decay of animal carcasses contaminated with short-lived isotopes (< 65 days).

a. Animal carcasses contaminated with short-lived isotopes may be held for decay by the Radiation Safety Office. The contaminated carcasses will be stored in a freezer dedicated for the purpose and posted as a Radioactive Materials Storage area.

b. Contaminated carcasses will be held for ten half- lives and surveyed to ensure that there is no activity detectable above background prior to final disposal.

c. If the radioactive biohazardous waste meets release criteria, it will be disposed of as biological waste by a licensed biohazard waste disposal contractor.

F. Mixed Waste

A mixed waste is a waste that is radioactive and also contains hazardous material. Mixed waste presents special problems in handling, storing, and final disposition. Prior to initiating work that will produce mixed waste all University personnel must receive RSC approval.

1. A material is considered Hazardous if it meets any of the following criteria:

a. Specifically listed in the 29 CFR part 1910, Subpart Z, Toxic and Hazardous Substances (the Z list);

b. The waste substance is listed in EPA Code of Federal Regulations Title 40, Resource Conservation and Recovery Act (RCRA);

c. Assigned a threshold limit value (TLV) by the American

Conference of governmental Industrial Hygienists, ACGIH);

d. Is determined to be cancer causing, an irritant, a sensitizer, or has damaging effects on specific body organs;

e. The substance exhibits any of the following characteristics:

(1) Ignitability
(2) Corrosivity (pH <2 or >12)
(3) Reactivity
(4) Toxicity

3. Please consult the RSO before initiating research that is likely to produce mixed waste. It is more expensive to dispose of mixed waste and some types of mixed waste are not currently accepted for disposal at all.

G. Improperly Packaged Waste

Radiation safety personnel may refuse to accept any waste that is improperly packaged. It will be the project personnel's responsibility to re-package the waste according to the Radiation Safety Office instructions.

H. Short Lived Waste (< 65 day half-life)

1. Short-lived wastes are segregated and stored according to isotope for a period of not less than 10 half-lives.

2. After the waste has decayed for 10 half-lives, it is surveyed to confirm that it meets unrestricted area release limits.

3. After survey, the waste is bagged and disposed at the regional class-D landfill as normal solid waste.

I. Waste Disposal Records

Disposal of all waste will be accounted for on the “Radioactive Waste Disposal Form” which is filled by the Responsible Investigator or his/her qualified designee. The completed form should agree with your isotope inventory.

1. Records documenting the transfer, processing, storage, and final disposal of radioactive wastes will be retained for a period of no less than five years form the disposal date or until authorized by the DHEC BRH.

a. Each container of waste will be given a unique identifier by the Radiation Safety Office and tracked by the project which generated the waste, isotope, activity, date of collection, and storage location.

b. Each container of waste will bear the following information:

(1) Rad waste identification number
(2) Description of the material (waste classification)
(3) Radionuclide and activity
(4) Project number and/or RI name
(5) Signature and date

XXIV. ATTACHMENTS

A. Attachment VI-1. Radiation/Contamination Survey Report

RADIATION SURVEY REPORT
Radiation Safety Section
Clemson University Research Safety

Building: Rich Room: 111 Survey Date:_____ Survey Time:_____ AM/PM

Project number(s) and Director(s):

Survey meter(s) :_____/_____
Make Model S/N Make Model S/N

☐ Check Source reading(s) within ±10%

LS Counter:_____
Make Model S/N

Surveyor Name:_____

Surveyor Signature:_____

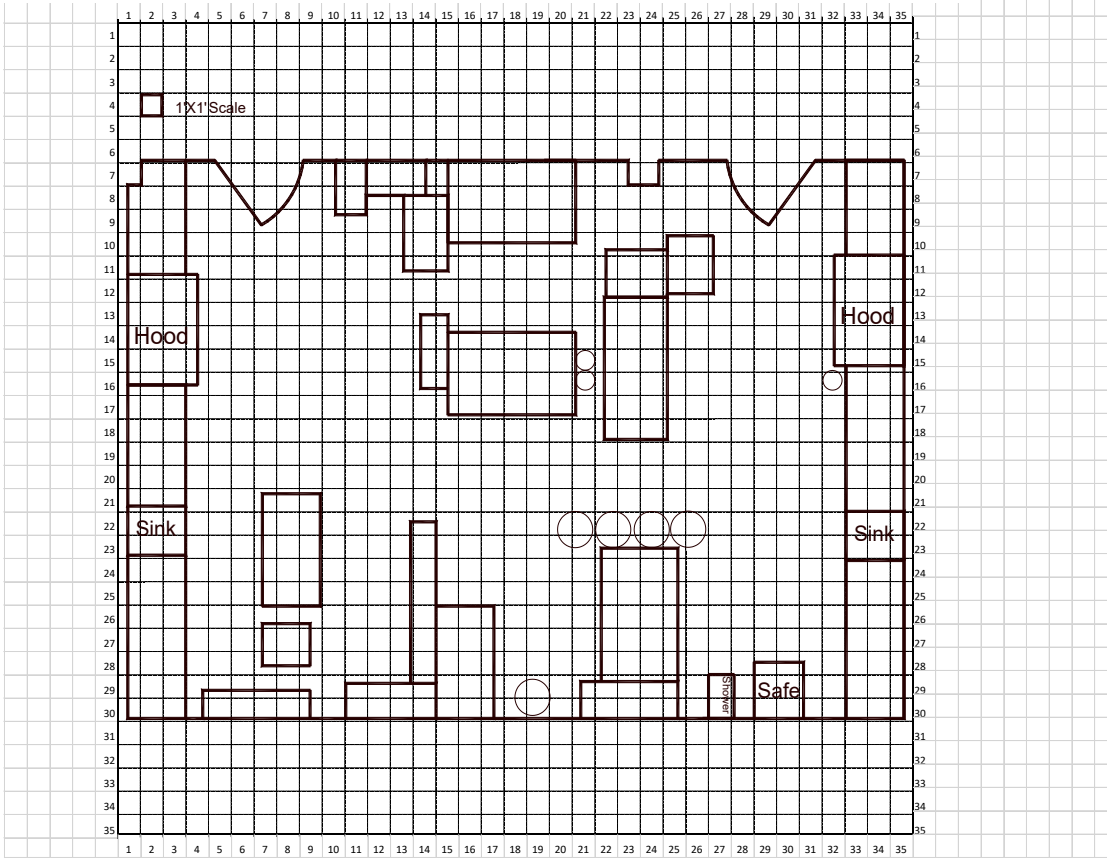
HP Review by:_____

CONTAMINATION SURVEY (dpm) - Working surfaces and floors are tested for removable contamination by wiping approximately 100 cm2. Contamination results are circled and are in units of desintegrations per minute (dpm). Results less than 100 dpm are reported as No Detectable Activity (NDA).

AREA RADIATION SURVEY (mR/h) - Radiation exposure rates aboce backgroudn are measured in units of milliroentgens per hour (mR/h). Readings are at waist level unless otherwised noted.

This report documents the conditions found at the time of the survey. Project personnel must conduct other surveys at meaningful times.

Each grid tile represents 1 square foot



_____ dpm Highest contamination level on floors or undesignated work surfaces

_____ dpm Highest contamination level on designated work surfaces

_____ mR/h Highest exposure rate in occupiable areas

_____ mR/h Highest exposure rate in nonoccupiable areas

B. Attachment VI-2. Sealed Source Inventory and Leak Check form

	Mnf	Type	SN	Isotope	Activity	Bld	Room	Freq	Last Inv.Date		Date Checked	Comment
SS-001	Agilent	ECD	L3847	Ni-63	15	Rich	114	6	8/2/2016	Active		HP GC SN 3336A53901
SS-002	Agilent	ECD	F1046	Ni-63	15	Rich	114	6	8/2/2016	Storage		uninstalled ECD under SN 33033A33129
SS-003	Agilent	ECD	U8466	Ni-63	15	Rich	114	6	8/2/2016	Active		Agilent GC SN US10521002
SS-004	Agilent	ECD	K1350	Ni-63	15	Rich	114	6	8/2/2016	Active		Agilent GC SN US00000609
SS-005	Agilent	ECD	U18370	Ni-63	15	Rich	114	6	8/2/2016	Active		Agilent GC SN US00042914
SS-006	Agilent	ECD	U17123	Ni-63	15	Rich	114	n	4/15/2015	Disposed		Shipped to Manufacturer 4/15/2015
SS-007	Agilent	ECD	U8465	Ni-63	15	Rich	114	n	4/15/2015	Disposed		Shipped to Manufacturer 4/15/2016
SS-008	Agilent	ECD	F1044	Ni-63	15	Rich	114	6	8/2/2016	Storage		uninstalled ECD under US10521003
SS-009	Agilent	ECD	U3272	Ni-63	15	Rich	114	6	8/2/2016	Storage		uninstalled ECD under US00042914
SS-010	Perkin Elm	LSC		Ba-133	0.0188	Rich	114	n	8/1/2016	Active		TriCarb 2910 TR LSC
SS-011	Beckman	LSC				LSF	260A	n	8/10/2016	Active		Beckman 6500
SS-012	PE Wallac	LSC		Eu-152		Rich	117	n	8/1/2016	Active		Wallac Quantalus 1220 SN 2200339
SS-013	Beckman	LSC	7070067			BRC	309	n	8/9/2016	Active		
SS-014	U of Kansa	Calibration	MRPUBE7(	Pu-239	994	Rich	117	12	8/1/2016	Storage		In storage, used once a year for calibration
SS-015	J.L.Shephe	Calibrator	A-872	Cs-137	300	RSF		6	8/17/2016	Storage		Instrument calibration source
SS-016	Amersham	Check Sour	AMM.2	Am-241	6.4	RSF		6	8/17/2016	Storage		leaking, for disposal
SS-017	Amersham	Calibration	SIC.10	Sr-90	20	Rich	117	12	8/1/2016	Storage		In storage, used once a year for calibration
SS-018	Amersham	Calibration	J502-80	Cs-137	97.6	Rich	117	12	8/1/2016	Storage		In storage, used once a year for calibration
SS-019	3M	Calibration	3B4J	Kr-85	10	RSF		n	8/17/2016	Active		
SS-020	Troxler	Density Ga	750-9006	Cs-137	9	ARTS		6	8/1/2016	Storage		in storage
SS-021	Troxler	Moisture G	750-9006	Am-241	44	ARTS		6	8/1/2016	Storage		in storage
SS-022	ORNL	Neutron So	SR-Cf-194	Cf-252	2.792	Rich	117	12	8/1/2016	Storage		In storage, used once a year for calibration
SS-023	Amersham	Calibration	J507-80-C	Cs-137	5	Rich	117	12	8/1/2016	Storage		In storage, used once a year for calibration
SS-024	Amersham	Calibration	J507-80-C(	Co-60	2	Rich	117	12	8/1/2016	Storage		In storage, used once a year for calibration
SS-025	Packard	LSC		Ba-133	0.0189	CETL	28	n	8/1/2016	Active		TriCarb 1000 SN 86633
SS-026	Wallac	LSC				Rich	B106	n	8/1/2016	Active		Wallac 1415 SN 4150005
SS-027	Troxler	Soil Moisture Probe		Am-241	50	Edisto		6	10/25/2016	Active		Edisto REC Soil Moisture Neutron Probe
SS-028		ECD		Ni-63	15	Baruch		6	10/24/2016	Active		Baruch
SS-029		ECD		Ni-63	15	Baruch		6	10/24/2016	Active		Baruch
SS-030		ECD		Ni-63	15	Baruch		6	10/24/2016	Active		Baruch
SS-031	Agilent	ECD	U25985	Ni-63	15	Rich	114	6	8/2/2016	Active		Agilent GC US00042914
SS-032	Agilent	ECD	U25986	Ni-63	15	Rich	114	6	8/2/2016	Active		Agilent GC US10521003
SS-033	Hidex	LSC				CETL	148	n	8/1/2016	Active		need info on standard source
SS-034	Spectrum	Check Sourc	661	Cs-137	0.001	Long	116	n	10/14/2016	Active		operational check source
SS-035	Spectrum	Check Sourc	691	Cs-137	0.001	RSF		n	10/24/2016	Active		operational check source
SS-036	Spectrum	Check Sourc	718	Cs-137	0.001	RSF		n	10/24/2016	Active		operational check source
SS-037	Spectrum	Check Sourc	160	Cs-137	0.01	Long	116	n	10/14/2016	Active		operational check source
SS-038	Beckman	LSC	7071579	Cs-137	0.03	EPL	105	n	9/2/2016	Active		
SS-039	NDC Techi	Film Thickn	12476	Am-241	150	RSF		6	10/24/2016	Storage		
SS-040	Perkin Elm	LSC	SGLO2516	Ba-133		CETL	141	n	9/16/2016	Active		
SS-041	Hitachi	LSC	204E7747	Ba-133		RSF		n	7/26/2016	Active		

C. Attachment VII-1. Form R-016 Radioactive Material Transfer Report

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The Office of Research Safety • 114 Long Hall
656-0341 • http://www.clemson.edu/research/safety/

RADIOACTIVE MATERIAL TRANSFER REPORT

Transferred from: RN- _____

Transferred radioactive materials:

Shipment Number	Isotope	Activity, µCi

Shipment Number	Isotope	Activity, µCi

Transferred to:

☐ Clemson University RAM Project RN-_____

I acknowledge receipt of the radioactive material listed above

Recipient RI Signature _____ Date _____

☐ External institution

Name _____

Address _____

RAM License # _____ Issuing State/NRC _____ Expiration Date _____

Packaging Information

☐ Exempt quantity ☐ Limited Quantity ☐ White I ☐ Yellow II ☐ Yellow III TI _____

Radiation level at the package surface: _____ mrem/h at 1 m from the package: _____ mrem/h

Survey meter serial number: _____ Calibration date: _____

External contamination swipe: _____ dpm

Swipe counter serial number: _____ Calibration date: _____

Carrier: _____ Tracking # _____

Transferor RI Signature _____ **Date** _____

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D. Attachment XII-1. RSOP-003 Radioactive Package Receipt

E. Attachment XXIII-1. Form R-013 Radioactive Waste Disposal Record

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RESEARCH SAFETY

The Office of Research Safety • 391 College Ave., Suite 104
(864) 656-0341 • http://www.clemson.edu/research/safety/

RADIOACTIVE WASTE DISPOSAL RECORD

Project: RN-____ Responsible Investigator (RI): _____ Room:_____ Building _____

Hazard Class: ☐ Corrosive ☐ Flammable ☐ Toxic ☐ Biohazardous ☐ Other: _____

Hazard(s): _____

Date	Isotope	Activity, µCi	Initials

Date	Isotope	Activity, µCi	Initials

Do not write below this line: for Radiation Safety Personnel only

Date collected _____ Collected By _____ Batch Number Assigned RW-_____

Form R-013 Page 1 of 1 Rev.1, September 14, 2016