UNCG Radiation Protection Policy

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1. General Policy & Administration

Radioactive materials and radiation generating devices are potentially hazardous unless used safely. To ensure safety, institutions and governmental agencies have established extensive regulations, rules and safety practices to minimize the impacts on the user, members of UNCG community and members of the general public. This policy manual sets forth the roles and responsibilities associated with the use of radioactive materials and radiation generating devices at UNCG as managed by the Department of Environmental Health and Safety (EH&S).

The North Carolina Department of Health and Human Services (DHHS) Radiation Protection Section has issued UNCG a License to procure, use, and store select radioactive materials under the regulatory provisions of 15A NCAC 11. DHHS also requires registration of radiation generating devices under the provisions of 15A NCAC 11. These devices include all x-ray producing equipment (analytical x-ray, bone densitometers, cabinet x-ray, electron microscopes).

1.1 Policy Statement

No one may use or bring into the University or remove from the University any radioactive materials or radiation generating devices without obtaining written authorization from the Department of Environmental Health and Safety. This includes registration of radioactive materials in consumer products that are licensed for sale to the general public and do not require any registration with governmental agencies.

All work with radioactive materials must comply with the conditions of use specified in (a) the License issued by the North Carolina Department of Health and Human Services Radiation Protection Section; (b) federal, state, and University regulations; and (c) the User Authorization issued by the EH&S Department.

No one may activate any radiation generating device unless it has been reviewed and approved by the EH&S Department and the operator has been instructed in the safe use of the device.

All persons who work with radiation sources must ensure that work-related radiation exposures are kept as far below the regulatory limits as reasonably achievable.

Radioactive waste must be handled in accordance with procedures established by EH&S and may not be disposed of as ordinary laboratory trash.

1.2 Program Administration and Responsibilities

The Associate Provost for Research and Public/Private Sector Partnerships through the Office of Research Integrity is responsible for the administration of the Radiation Safety Committee (RSC). The RSC is a University standing committee consisting of faculty and administration that sets UNCG licensed activity related policy and oversees the Radiation Safety Program. The Radiation Safety Program is administered by the Department of Environmental Health and Safety, a department in Business Affairs which is under the direction of the Vice Chancellor of

Business Affairs. The Radiation Safety Officer (RSO), in the EH&S Department, is responsible for the day-to-day operations of the Radiation Safety Program.

The RSC issues Authorizations to those holding University appointments (faculty and officers) to use and supervise the use of radiation sources. The Authorization specifies the conditions of use (type, quantity, location, protocols). Registered Workers are the trained students, staff and others who use radiation sources under the supervision of an Authorized User.

1.3 The Radiation Safety Committee

The Radiation Safety Committee is the governing body for all aspects of radiation protection within the university, including all affiliated research, clinical, instructional and service units using radiation sources in facilities owned or controlled by the university. The Committee shall ensure that all possession, use and disposition of radiation sources by university personnel at UNCG complies with pertinent federal and state regulations and with the specific conditions of licenses issued to the University, and that all concomitant radiation exposures are maintained **A**s **L**ow **A**s **R**easonably **A**chievable (ALARA).

The committee is a University Standing Committee that is responsible for the oversight of the University Radiation Safety Program. In fulfillment of this role, the Committee promulgates policies, rules and procedures for the safe use of radiation sources. The Committee has the authority to grant, deny, or withdraw permission for the use of radioactive materials or any other radiation sources within the University. It is the intent of the University that no use of radiation shall proceed without the knowledge and approval of the committee.

The RSC is to be made up of at least one member from each department that is authorized for the use radioactive isotopes in research. The members of the RSC are appointed by a process defined by the Office of Research Integrity. The Radiation Safety Officer is a standing, voting member of the RSC. The Research Compliance Officer is an ex-officio member of the RSC. All members of the RSC are voting members. Up or down votes regarding committee actions are completed by a process of majority vote.

The committee reports to the Associate Provost for Research and Public/Private Sector Partnerships. In its oversight role of the Radiation Safety Program, the committee is responsible for the following:

- Establishing policies regarding approved protocols;
- Establishing training procedures and criteria;
- Review and approval of all proposals for radionuclide use and conditions of use;
- Ensuring that only qualified individuals are Authorized to use radiation sources;
- Enforcing compliance with federal and state regulations, as well as UNCG polices and User Authorization conditions;
- Voting to change service vendors as may be required by license, regulation, or commercial requirements;
- Making recommendations to the Assoc. Provost for Research and Public/Private Sector Partnerships on risk management issues related to radiation safety.

1.4 Department of Environmental Health and Safety

The Department of Environmental Health and Safety is responsible for implementing the Radiation Safety Program, which includes:

- Maintaining a registry of all persons and facilities authorized for radiation use;
- Monitoring users' procurement, transportation, storage, use, and disposal of radioactive materials, to ensure compliance with state and federal regulations;
- Auditing approved authorizations and programs annually, through meetings with authorized users and inspection of operations;
- Reviewing laboratory operations to determine compliance with the ALARA principle;
- Provide radiation safety training for all radiation users;
- Assisting in storage, use, and waste disposal problems at the laboratory level;
- Calibrating survey meters;
- Operating a radioactive waste management program. The program includes receipt of wastes, decay-in-storage, and disposal through commercial vendors;
- Review release records of users, to ensure compliance with regulatory limits;
- Providing personnel monitoring and bioassay services;
- Responding to emergencies and supervising decontamination operations by the authorized user;
- Investigating incidents involving radioactive materials and violations of regulations;
- In cases of noncompliance, suspending authorizations in accordance with guidelines established by the Radiation Safety Committee;
- Conducting periodic leak testing of sealed radioactive sources as required by NCDHS regulations or the UNCG license;
- Conducting a semiannual inventory of all radioactive materials and radiation generating devices;
- Maintaining complete records of program operations that are in a form suitable for inspection by regulatory agencies and can be readily retrieved and distributed.

1.5 Radiation Safety Officer

The duties, responsibilities, and authority of the Radiation Safety Officer consist of:

- Day-to-day coordination and management of the Radiation Safety Program;
- Advising on implementation of all aspects of the Radiation Safety Program, including safety and cost-effectiveness;
- Executing the established policies of radiation protection and ensuring compliance with federal, state and local regulations;
- Supervising radiation control activities as required by the Radiation Safety Program and the RSC;
- Establishing action levels for personnel exposure, radiation and contamination limits;
- Investigating all proposals for radioactive material and radiation generating device use, use conditions, and the transmittal of proposals to the RSC, with recommendations for approval or disapproval;

- Providing provisional approval to satisfactory proposals in accordance with the guidelines of the RSC;
- Halting operations involving radioactive materials and radiation generating devices if unsafe or unacceptable conditions exist;
- In certain cases of noncompliance, suspending authorizations to use radioactive materials and radiation generating devices in accordance with guidelines established by the RSC, and authorizing provisional reinstatement following achievement of compliance pending review and final action by the Radiation Safety Committee;
- Performing an annual review of the Radiation Safety Program;
- Briefing senior management at least annually on the conduct of the licensed activities.

1.6 Ensuring Compliance with Radiation Safety Policy

The University has promulgated a strong enforcement policy to maintain high standards for radiation protection. DHHS regularly inspects University laboratories for compliance and emphasizes the need for "meticulous attention to detail and a high standard of compliance with regulations." Adverse findings by DHHS can result in the suspension of the University License to use radioactive materials or radiation generating devices, which would impair the University's research programs. Accordingly, the Radiation Safety Committee takes whatever measures it deems necessary to achieve compliance with governmental regulations.

The Radiation Safety Committee has promulgated a schedule of mandatory suspensions of authorizations, with the penalties dependent on the severity and frequency of observed violations. The suspension is effected by the Radiation Safety Officer as the agent for the Radiation Safety Committee. The Radiation Safety Officer will suspend the use of radioactive materials or radiation generating devices for any of the actions listed below, to ensure safety and to correct regulatory compliance issues or at the direction of the Radiation Safety Committee. Under the terms of this suspension, all radioactive materials or radiation generating device work covered by the Authorization must stop and no new purchases will be authorized.

The Authorization may not be reinstated until the Authorization Holder ensures effective resolution and documents the incident and corrective actions in writing to the Radiation Safety Committee. The Radiation Safety Officer has the authority to reinstate an authorization for an interim period until the next meeting of the Radiation Safety Committee with the satisfactory completion of an audit. This audit will review compliance with the conditions of the Authorization and implementation of measures to prevent recurrence of violations. A suspended authorization will not be fully reinstated until the incident is reviewed by the RSC and the Committee is assured that reasonable measures have been instituted to prevent recurrence. A committee meeting to review a suspension shall be attended by the Authorized User in violation and the chair of the department.

Enforcement Actions are ranked as follows:

A. Those for which a single occurrence will result in a suspension of the authorization:

- Radioactive waste in an unlabeled trash container;
- Unsecured radioactive materials.

B. Incidents that occur twice in a twelve-month period:

- Use of radioactive materials or a radiation generating device in an unauthorized space;
- Pipetting radioactive materials by mouth.

C. Three occurrences of any particular incident in any twelve-month period:

- Working with radioactive materials or radiation generating devices before successfully completing initial or annual Radiation Safety training;
- Failure to record monthly inventory statements;
- Failure to record use on daily use log;
- Failure to document required contamination surveys;
- Failure to record a sink disposal;
- Not wearing appropriate dosimetry and protective clothing;
- Not reporting a spill of greater than 1 mCi or outside an unauthorized area;
- Not performing personal surveys before leaving the laboratory;
- Not completing a bioassay (The worker is immediately suspended from working with radioactive material until the bioassay is completed);
- Not ensuring annual calibration of survey instruments;
- Not defacing radioactive warning labels on empty containers and boxes prior to disposal as ordinary trash;
- Not labeling radioactive materials or equipment;
- Evidence of eating, drinking, or smoking in laboratories;
- Storing food or beverages in laboratory;

In addition to the conditions for mandatory suspensions noted above, the Radiation Safety Officer may halt operations involving radioactive materials whenever unsafe or unacceptable conditions exist.

Typically, laboratories are assigned to and are under the direction of a single Authorized User. However, there may be cases where multiple Authorized Users share a space. For shared laboratory spaces, any charges assessed by the EH&S Department will be evenly distributed between the Authorization Holders. In the event of enforcement actions taken against a shared laboratory space, the EH&S Department will work with the Authorized Users to identify the individual responsible for the incident. If however the responsible party cannot be identified, the incident will be assigned to all Authorized Users using the laboratory.

2. Authorized Users and Registered Workers

The **Authorized User** is an individual authorized by the Radiation Safety Committee to use and supervise the use of radioactive materials or radiation generating devices. A **Registered Worker** is an individual (faculty, staff, student) approved to use radioactive material or radiation generating devices under the supervision of an Authorized User.

2.1 Authorized User

Any purchase, use or work undertaken with radioactive materials or radiation generating devices requires written authorization, referred to as an Authorization, from the Radiation Safety Committee.

To obtain an Authorization, a qualified individual must submit an application (Appendix A) to the Radiation Safety Officer, who will review it and add it to the next RSC meeting agenda.

The evaluation of an application to hold Authorized User status includes the following:

A. Identification and review of the types and proposed uses of all radiation sources in the application form. This review and subsequent Authorization approval is based on the radioactivity used at one time or the design parameters of the radiation generating device. Requests that include the possession of radioactive material will consider the amount used at one time, with purchase limits that are adequate to cover the laboratory operations. In addition, the applicant must agree to abide by all policies and procedures for acquisition, use, storage and disposal of radioisotopes.

B. The applicant must meet the requirements of a Qualified User (see below), by demonstrating the appropriate education, training, and practical experience commensurate with the radiation sources to be used. If the applicant does not meet these requirements, (s)he may, with the approval of the Radiation Safety Committee, delegate responsibility for all uses of radiation under the authorization to a Qualified User under his or her direct supervision. A Qualified User is an individual who has:

    1) A college degree at the bachelor level or equivalent training and experience, in the physical, biological, or engineering sciences;
    2) Provided evidence of adequate training commensurate with the proposed use of radiation and is qualified to work independently with radiation sources and to supervise such use by others. This training may be accomplished either within the institution or on the basis of documented prior training or by testing to document adequate knowledge.
    3) Satisfactorily completed the EH&S Department Seminar in Radiation Safety.

C. The applicant is interviewed by the RSO or a RSC Committee member for the appropriate training, experience, and understanding of the University's Radiation Safety Policies and Procedures. The laboratory facilities are reviewed against the

design criteria; laboratory experimental technique is discussed; and access to appropriate instrumentation is verified.

D. The RSO will audit to verify that the applicant satisfactorily complies with the requirements of this section. Following successful conclusion of this audit, the Radiation Safety Officer will make a recommendation to the Radiation Safety Committee requesting approval of the Authorization. At the meeting, the Radiation Safety Committee reviews the application and votes by majority rule, to accept, modify, or deny the application. Alternatively, the Department of Environmental Health and Safety may seek Radiation Safety Committee approval by paper or electronic mail ballot. Approval by the Radiation Safety Committee is finalized by a designated representative of the Radiation Safety Committee (usually the Chair) but not by the Radiation Safety Officer.

2.2 Authorization Amendments

All requests for amendments must be submitted in writing to the Department of Environmental Health and Safety. Amendments include changes to authorized radionuclides or devices, experimental protocols, possession limits, and registered rooms and radiation. The EH&S Department will review the requested amendment with the Authorization holder or his/her designee. The RSO can approve simple changes in experimental protocol, possession limits, rooms and users, and addition of similar radioactive materials or devices, upon completion of the appropriate paperwork. Any other change of an Authorization condition, including addition of a new type of radioactive material or radiation generating device, large increase in possession limits, or complex experimental protocols must be approved by the Radiation Safety Committee. Any changes approved by the RSO will be presented to the Radiation Safety Committee for confirmation.

2.3 Authorization Termination

Authorization to use radioactive materials or radiation generating devices terminates when the Authorization Holder leaves the University or requests the termination of the Authorization. The Authorization Holder must notify the Radiation Safety Officer at least 30 days before leaving the University or terminating an Authorization. The Authorization Holder must ensure the proper transfer of materials, devices and records and the completion of appropriate bioassays and laboratory termination surveys before leaving the University or terminating the Authorization.

2.4 Authorized User Responsibilities

The Authorized User is responsible for ensuring that any radiation related activities carried out under their Authorization are in compliance with the conditions of their Authorization, the UNCG Radiation Safety Policies and Procedures manual, and any notices issued by the EH&S Department. These responsibilities include, but are not limited to:

- Maintaining an up-to-date listing with the EH&S Department of radiation generating devices, use protocols, rooms where radioactive materials or radiation generating devices are used or stored, and names of personnel who may use these devices and materials;
- Ensuring that laboratory staff, follow the Registered User Responsibilities;
- Allowing only trained Registered Users to use radioactive materials or radiation generating devices;
- Contacting the EH&S Department before:
  - starting a new procedure that varies from the authorized protocols;
  - renovating, altering, repairing or vacating any laboratory space;
  - changing laboratory locations or leaving the University;
  - repair, transfer or disposal of any radioactive-use equipment;
  - Allowing students under 18 (including emancipated minors) to be involved in experiments using radioactive materials or radiation generating devices. (Must complete the Notification of Minor Using Radiation form)
- Ensuring those working under his/her Authorization are adequately trained before working with sources of radiation. This training includes satisfactory completion of the EHS Radiation Safety Seminar, as well as instruction on laboratory specific safety practices, techniques, and procedures.
- Minimizing radiation exposures to the Registered Users, University Community, environment, and general public;
- Ensuring that dosimetry is used and stored appropriately and returned on time;
- Maintaining daily use and monthly inventories of radioactive materials
- Maintaining security of radiation generating devices and radioactive materials
- Controlling the purchase, possession, use, transfer and/or disposal of radioactive materials or radiation generating devices in his or her possession;
- Maintaining records of purchase, receipt, use, surveys, and disposal;
- Minimizing and properly packaging radioactive wastes;
- Complying with the University's policy governing the use of radioactive materials and radiation generating devices to ensure compliance with governmental regulation;
- Complying with any special conditions listed on his or her Authorization;
- Implementing the policies of the Radiation Safety Manual;
- Notifying the EH&S Department 30 days before vacating a room designated as a radiation use area on their Authorization. Ensuring that the laboratory is properly surveyed for the presence of radioactive materials and all radioactive materials and radiation generating devices are disposed of as waste or transferred to other authorized users before leaving the premises.

2.5 Radiation Worker Registration

No one should begin working with radioactive materials or radiation generating devices without first registering with the EH&S Department under a specific Authorized User's Authorization, satisfactorily completing Radiation Safety training, and receiving dosimetry (if required). The Radiation Worker Registration Form can be found in Appendix A. For a schedule of training

classes please contact the EH&S Department directly or visit their website at http://www.uncg.edu/sft/.

2.6 Registered Worker Responsibilities

Persons who use radioactive material and radiation generating devices must follow all applicable regulations pertaining to the use of radioactive materials as presented in UNCG Radiation Safety Policies and Procedures, in the Authorization issued to the Authorized User, and in notices issued by the EH&S Department. Radioactive materials and radiation generating devices must be handled in a manner that also ensures the health and safety of others and protects the environment. In addition all users must:

- Register with and receive training and approval from the EH&S Department prior to using any radioactive source or radiation generating device;
- Comply with the conditions on the laboratory's Authorization;
- Receive appropriate instruction from the Authorized User on lab specific procedures before working with radioactive materials or radiation generating devices;
- Wear radiation dosimetry (if assigned) and participate in required bioassays;
- Wear required personal protective equipment when handling radioactive materials:
- Safety glasses, lab coat, long pants, close toed shoes, and appropriate gloves for the biological or chemical components of the material being used;
- Take steps to minimize radiation exposure. Increase distance and shielding and perform "dry runs" to increase efficiency and decrease time spent handling material;
- Follow the requirements of Section 6 when moving radioactive material between buildings, across campus to another facility or institution;
- Maintain records as required by the Radiation Safety Manual or the EH&S Dept.;
- Complete a thorough personal and area radiation survey before leaving the laboratory after using radioactive materials.

2.7 Training

All radioactive materials users must take the Radiation Safety Training Seminar given by the EH&S Department. Refer to the EH&S Department website for a schedule. The EH&S Department may require additional training and suitable experience for specific proposed projects. Radiation generating device users need to take device specific training as determined by the EHS Department.

All maintenance and other workers who need to enter a controlled area must receive suitable instruction from the EH&S Department, or be directly supervised by a registered worker while in the laboratory.

2.8 Minors and Radioactive Materials or Radiation Generating Devices

No person under 18 years of age is allowed to be in a laboratory that contains radioactive materials unless the person is first approved by the EH&S Department and completes the notification in Appendix A. Such persons must be University employees or University students.

No person under the age of 16 is allowed to be in a laboratory that contains radioactive materials or a radiation generating device.

2.9 Special Considerations for Classroom Radioactive Material Use

Radioactive materials, other than sealed sources of exempt quantities, may be used for teaching and demonstration in academic classes only if that provision is included in a valid Authorization that has been approved by the Radiation Safety Committee. The following information needs to be provided:

1. Name and radiation experience for the laboratory instructor(s);
2. Course duration and title;
3. A description of the proposed use, procedures, radiation safety instructions and description of the student's involvement with radiation;
4. Expected number of students (the Authorization Holder will forward the name and birth date of all students at beginning of each semester);
5. Number of laboratory groups and number of students per group.

3. Purchase or Procurement

No one may order, receive, use, or bring into the University any radioactive material without prior authorization from the EH&S Department. This includes purchases from commercial vendors, other universities or transfers from colleagues or gratis shipments from commercial vendors. Persons wishing to acquire radioactive materials need to contact the EH&S Department for authorization.

3.1 Ordering Radioactive Materials

Before ordering a radioactive material, first ensure that the sum of the proposed order and the amount you already have on-hand does not exceed the Authorization's possession limit. If the total purchase plus inventory would be less than the possession limit, approval may be obtained by contacting the EH&S Department. Authorization is given for specific radioactive materials and possession limits, and may also designate the compound and physical form.

All orders will be placed through the RSO and the EH&S Department. A purchase request form (Appendix A) is to be completed and faxed or delivered to the EH&S Department for any purchase of regulated radioactive materials. At his/her discretion, the RSO may require a review of the Authorization, including protocols, lab facilities, users and training prior to approving and placing orders for radioactive materials.

3.2 Ordering Radioactive Materials For Delivery to Other Institutions

Radioactive materials ordered for delivery to another institution are not ordered under the UNCG License. These materials must first be approved for delivery by the destination institution. These materials may then be ordered under the destination institution's radioactive materials license. The individual laboratory ordering these materials is required to maintain records of this purchase.

3.3 Receiving Radioactive Materials

All packages delivered to UNCG will be received by the EH&S Department, whereupon the package will be inspected for signs of damage and surveyed for surface contamination and external radiation levels, as required by the Department of Transportation. The source vial will also be checked for surface contamination, the isotope and activity will be verified against the purchase requisition, and a unique serial number will be assigned to the item. Acceptable packages and a daily use/inventory log will then be delivered to the laboratory by EH&S personnel. If a registered radiation user is not present to sign for the package, it will be stored at the EH&S Department. Receipt records will be maintained by the EH&S Department.

Upon receipt, the lab is responsible for transferring the material to a secure location and maintaining an accurate inventory until the item is completely decayed, disposed of as radioactive waste, or transferred to another User or institution. Completely deface any radiation labels prior to disposal of packaging in ordinary trash.

3.4 Inventory

Regulations require accurate up-to-date inventory of each radioactive material under the laboratory's possession. To ensure proper reconciliation, each source vial will be marked with a unique serial number that is also recorded on the Daily Inventory Log (Appendix A). Each user will record the date, activity (mCi), and disposition (transfer, waste, etc.) of all material removed from the stock vial on the Inventory Log. Mark disposal date on the bottom of the inventory form. These inventory records are used to complete a semi-annual University-wide inventory conducted by the EH&S Department. Radioactive material inventory forms must be maintained for three years after transfer or disposal of the material.

3.5 Transfer of Radioactive Materials

Since possession of radioactive materials is covered by the requirements of a radioactive materials license, all transfers of a radioactive material must have prior approval by the EH&S Department. Radioactive materials can only be transferred to another Authorized User, either at the University or another institution. If the transfer is to another institution, allow enough time for the EH&S Department to work with the other institution's Radiation Safety Office and complete the appropriate paperwork. The Authorized User is responsible for maintaining records of all transfers of radioactive material, both within the University and to other institutions.

3.6 Shipping & Transportation

Transportation of radioactive materials is regulated by DHHS and the US Department of Transportation (DOT), and must also meet the requirements of the carrier and destination licensee. To ensure that all regulatory requirements are met, any shipping or transportation of radioactive materials must be approved by the EH&S Department.

Radioactivity may be hand carried between University buildings with prior approval from the EH&S Department.

All shipping or transportation of radioactive material off-campus must be approved by the EH&S Department. Radioactive material must meet the packaging, labeling, and documentation requirements of the DOT. All materials should be transported by either a University owned vehicle or a commercial carrier. Under limited conditions, radioactive materials may be transported locally in a private vehicle by a trained and authorized individual.

4. Working With Radioactive Materials

4.1 Authorized Laboratories

Radioactive Materials may only be used in laboratories and rooms that are listed on an Authorization approved by the Radiation Safety Committee. An Authorization User may add a new room by filing an amendment to his/her Authorization. As part of the Authorization process, the EH&S Department will review the laboratory space for the proposed purpose. This includes determining the survey frequency, posting requirements, security review and special considerations with the particular experimental protocols.

4.2 Facility Requirements

Authorized laboratory facilities shall have nonporous surfaces and meet laboratory ventilation requirements. Iodinations shall be done in laboratory hoods vented to the atmosphere through the building ventilation system. All laboratories authorized for the use of radioactive materials should have:

- Entries posted with a "Caution Radioactive Material" sign;
- Bench tops and floors finished with nonporous and easily cleanable surfaces;
- Nonporous walls covered with easily cleanable paint;
- A high-quality chemical resistance fume hood suitable for work with radioactive vapors, dusts, fumes and gases with a minimum face velocity of 100 fpm;
- Facilities to adequately secure radioactive materials.

For a larger or unusual radiation related projects, the EH&S Department may add guidance from the International Atomic Energy Agency (IAEA) safety guide, Safe Use of Ionizing Radiations in the Workplace for evaluating laboratories that use radioactive materials or the National Radiological Protection Board's Categorization and Design of Working Areas in which Unsealed Radioactive Materials are Used.

4.3 Posting Requirements

Posting areas that use radioactive materials or radiation generating devices warns people about the potential for radiation exposure and meets regulatory requirements. The DHHS Radiation Protection Section regulations define conditions under which signs and labels must be used to alert people to the presence of radiation and radiation sources.

To ensure that building occupants are properly notified of their rights and responsibilities associated with radioactive materials and radiation generating devices, the DHHS Notice to Employees shall be posted in a conspicuous location.

The entrance to each laboratory that uses radioactive materials or radiation generating devices shall be posted by the EH&S Department with the appropriate signage before radioactive materials or radiation generate devices are used. This laboratory posting will also include emergency contact information for the laboratory. It is the laboratory's responsibility to ensure

that this information is up-to-date. These signs may only be removed by or with authorization from the EH&S Department.

Mark laboratory equipment such as beakers, flasks, centrifuges, test tube racks and pipettes used for radiation work with a radiation symbol to minimize the potential for inadvertent contamination. Containers that may be used for transitory use of radioactive materials and will not be left in a contaminated state do not need to be posted if they are under the direct control of a registered user. Post all storage containers with a "Caution Radioactive Material" label that includes the radiation symbol, radionuclide, activity and reference date.

Prior to disposal of any laboratory equipment or supplies that have been used with radioactivity, survey the material with an appropriate instrument to ensure that it is not contaminated and remove all radiation labels or markings.

4.4 Radioactive Material Security

Secure all stock solutions, sealed sources, activated materials and other than trace quantities of waste from unauthorized removal or access by locking either the room or the container. Store radioactive materials only in areas identified on your Authorization. Record all dispensing, transfers, or decay of radioactive materials on the Daily Inventory Log (Appendix A). Post the log near the storage container or in a designated notebook. Retain the inventory log form for three years after the radioactive material is either decayed to background or disposed of as radioactive waste.

Control and maintain constant surveillance of radioactive materials when they are not in storage and prevent unauthorized access or removal by questioning any laboratory visitors.

Any of the following methods of security are acceptable:

- Store radioactive material inside a locked laboratory room. When the room is locked it is not necessary to physically secure the radioactivity inside the laboratory. When the door is unlocked, a trained radiation worker must maintain surveillance over the radioactive material and restrict access to the radioactive material to authorized radiation workers.

- Store radioactive materials in a locked container such as a freezer or other container that cannot be removed.

- Store radioactive materials in a lock box or specialized container. Physically secure these containers to an immovable object in the lab so they cannot be removed from the laboratory.

- Liquid solutions may be secured by placing the material in a locked automated dispenser that cannot be removed from the laboratory.

4.5 Unsealed Radioactive Materials

The hazard from unsealed sources of radioactive material is primarily the exposure risk from ingestion, inhalation, or skin contact. An external exposure hazard is also presented by gamma and high energy beta emitters (^{32}P). The protective measures used to prevent personal contamination or uptake of radioactive materials into the body are similar to those used in handling of other hazardous chemicals and are consistent with prudent laboratory practices. While governmental regulations must be observed in detail, a few basic rules are critical to protecting workers and the environment from the risk of exposure. These are:

1. Designate a radiation work area. This area should be space away from high traffic areas and should contain all of the materials and resources necessary for procedure. Cover this area with absorbent paper and mark the area with 'Caution Radioactive Material' tape;
2. Post areas with warning signs and label all radiation sources and equipment used with radioactive materials;
3. Wear lab coats, gloves that are appropriate for the biological and chemical materials being used, safety glasses, close-toed shoes and long pants to minimize the chance of personal contamination;
4. Be careful not to cross contaminate laboratory equipment. Remove gloves and lab coat and perform a personal survey before leaving the laboratory;
5. Perform a "dry run", using stable or a small amount of radioactive material, to perfect your technique and identify potential problems;
6. Control time, distance, and shielding to keep potential exposures ALARA.
7. Use materials with the potential for vapors or gas release in a fume hood or glove box approved by the EH&S Department. Refer to Section 4.7 on volatile materials.
8. Use a secondary collection flask and in-line filter to prevent contamination of pumps or the central vacuum lines, or accidental releases;
9. Do not store or consume food or beverages in rooms where unsealed radioactive materials are used or stored;
10. Do not dispose of any radioactive waste as normal laboratory trash. Monitor trash containers to detect accidental disposal of radioactive materials. Dispose only in accordance with the procedures set forth in Section 15 of this document and maintain records of disposal, as required;
11. Sewer release may only be done via registered sinks and must be done in accordance with the approved guidelines of this document (Section 9.9) and the Authorization;
12. When finished working with radioactive materials or if leaving the laboratory, secure all radioactive materials, complete personal and area radiation survey and wash hands. Record the results of the survey when working with more than 1 mCi;
13. Keep yourself informed of all safety measures pertaining to your work, as stated in this document, your Authorization, and EH&S Department notices;
14. Immediately notify the EH&S Department (334-4357) of known or suspected:
    - Accident or spill of radioactive materials;
    - Accidental release of radioactive materials to the atmosphere, drains, ventilation system or laboratory or building services;
    - Loss of radioactive material;
    - Personal contamination or uptake (inhalation, ingestion or injection)

4.6 Sealed Sources

Sealed sources are radioactive materials that are encapsulated or enclosed, in accordance with rigid specifications, to prevent leakage. Sealed sources may be in the form of disks, foils, seeds, wires or welded capsules. The hazard from these sources is external exposure to the radiation emitted from them. Unlike unsealed sources, sealed sources do not present contamination problems unless the integrity of the source has been compromised. However, the sources are usually larger and may present a significant external exposure hazard. Users can limit excessive external radiation exposure and ensure regulatory compliance by following a few basic rules. These are:

- Always wear whole body or finger dosimetry (if assigned);
- Reducing TIME spent handling or near radioactive sources by performing a "dry run", without radioactivity, to improve efficiency and identify potential problems;
- Increase DISTANCE by using tongs or other handling tools;
- Use appropriate SHIELDING to limit the radiation field size (see Section 5.3 for appropriate shielding considerations);
- Use an appropriate detection instrument to verify where the radiation field exists and to ensure that the dose rate in any uncontrolled area does not exceed 2 mrem/hr;
- Keep sources secured in shielded containers when not in use.

4.7 Volatile Materials

Some radioactive material compounds may be naturally volatile or may volatilize during use. Examples of these radionuclides are sodium iodide, ^{35}S-methionine, sodium borohydride, succinic anhydride and acetic anhydride. Additionally, it is possible for other compounds to release radioactive materials, such as tritiated water, when they are heated. Volatility significantly increases the possibility of exposure without appropriate control measures. As a result of these concerns, bioassays are often required for those working with a volatile radioactive material.

To minimize radiation exposure for volatile radioactive materials, always work in a properly calibrated (within the last year) and functioning fume hood. Operate the fume hood with the sash at the proper height with an unobstructed air flow. Proper use of a fume hood will eliminate the need for respiratory protection. Additional measures to limit volatility include minimizing the number of freeze/thaw cycles, the use of charcoal adsorbents, evacuating volatilized material before use and removing aliquots through a septum top.

5. Laboratory Surveys

The Radiation Safety Officer conducts random quarterly surveys of all radiation laboratories. However, one of the most important components of any radiation protection program is the laboratory's own surveys. User surveys are required as follows:

- A wipe test shall be performed and documented within seven days following the use of any unsealed radioactive material.
- An external radiation (meter) survey must be performed and documented within seven days following the use of any gamma or high energy beta emitter.

5.1 Wipe Tests

A wipe test is simply a check for removable surface contamination by wiping areas with filter paper and then counting the wipes in a liquid scintillation counter (LSC). To perform a wipe test, identify and record areas to be wiped. With a gloved hand wipe areas of about 100 cm^2 with filter paper. Prepare the samples for the LSC by placing the filter paper in a liquid scintillation vial with a sufficient quantity of environmentally-safe scintillation cocktail, and count in an LSC. It is also necessary to establish a background level. To do this, follow the above procedure using an unused filter paper. Be certain that the LSC is set up to count all the isotopes that are used in your laboratory.

Wipe test results must be recorded in net DPM (disintegrations per minute, minus background sample). The LSC may present results in CPM (counts per minute), which is the number of decay events detected by the LSC. To convert to DPM, divide the CPM by the counter efficiency. If not known, the LSC efficiency can be assumed to be 20% for ^3H and 50% for all other nuclides.

While any excess removable contamination should be cleaned to keep personnel exposure ALARA, the action level for required decontamination of laboratory areas is 600 DPM/100cm^2. The action level for posted dedicated equipment (centrifuges, incubators, water baths, etc.) is 2000 DPM/100cm^2. Any wipes exceeding the appropriate action level must be decontaminated promptly and repeatedly until post-decontamination wipe test results are below the action level.

Documentation of required contamination surveys shall include the date, surveyor name, building and room number(s), radionuclide(s) used, location of wipes (preferably a map), and wipe results (net DPM). Additional, post-decontamination wipe results shall also be recorded for any wipes exceeding the action levels. All survey records shall be maintained in the radiation safety notebook for three years.

5.2 External Radiation Surveys

An external radiation survey, also known as an Area or Meter survey, and personal surveys should be conducted daily following the use of radioactive materials (except ^3H). An area

survey must be documented within 7 days of use of any gamma or high energy beta (^{32}P) emitter.

With the appropriate meter and probe, a meter survey is conducted by slowly passing the probe over the area or object to be surveyed. Check the batteries and calibration due date prior to beginning the survey. Be certain to survey at a constant speed – approximately 5 cm/sec. The distance from the surface or object should also be constant. A distance of 1 cm is suggested. Be careful not to contaminate the probe. Survey your lab coat, shoes, face, hair, and gloves to make sure you are not contaminated. If you detect any personal contamination, immediately contact the EH&S Department at (336-334-4357). Survey bench tops, floors, cabinets, and equipment for contamination. Monitor nonradioactive (laboratory and hazardous) trash containers to ensure that radioactive waste is not improperly disposed of in these waste streams. Survey radioactive storage and waste containers to ensure all areas are below 2 mrem/hr, measured at one foot from the outer container.

Documentation of required meter surveys shall include the date, surveyor name, meter serial number and calibration due date, areas/items surveyed (preferably a map), and results. Results shall include background readings, and readings for any areas greater than background or a statement affirming all readings are $\leq$ background.

Personal and area surveys are not required for ^{3}H use, as it cannot be detected with a meter.

5.3 Selection and Use of a Survey Meter

Each portable radiation survey instrument has different detection capabilities. There are 3 common categories: Geiger-Muëller, scintillation, and ionization chambers. Typically, labs do not use an ionization chamber. Choose the hand-held survey meter or instrument appropriate for the radionuclide from Table 2. In general, for betas, choose a pancake probe (preferable) or other thin window Geiger-Muëller probe.

Geiger-Muëller Detector

The Geiger-Muëller (GM) counter is the most common radiation detection instrument on campus. A GM counter provides both visual and audio responses to radiation. The meter detects radiation events and does not differentiate types of radiation or energies. For this reason, the GM is primarily used to DETECT radiation and may not accurately measure exposure rate.

The GM probe has thin 'window' at one end that is very fragile. This probe is used for detecting beta emitters (e.g. ^{32}P, ^{35}S, and ^{14}C). However, ^{3}H is not detectable since it does not have enough energy to penetrate the window. ^{14}C and ^{35}S emit betas energetic enough to pass through the thin window, but detection efficiency is low and greatly impacted by distance. Instead, use a liquid scintillation counter.

Low energy betas may not be detectable if the probe window is covered with paraffin film, plastic wrap, or other protective material. The efficiency for higher energy betas will also be

reduced with any covering. Because radioactive decay is random, the meter reading, at low count rates, often fluctuates widely. For this reason, the audio speaker is sometimes a better indicator of small amounts of radioactivity. At higher count rates, the speaker response is often faster than the meter reading. It is better, therefore, to have the speaker on and the response set to fast, "f", on the f/s switch, when using a survey meter to look for contamination. Once contamination is found, switch to slow ("s") response to measure the count rate.

Scintillation Detector/Probe

Scintillation detectors absorb radiation and emit light that is converted into a radiation measurement. There are two types of scintillation detectors a hand-held instrument and a liquid counting system.

The liquid Scintillation Counter (LSC) can detect and quantify a broad range of radiation types and energies and is used to count experimental samples and contamination survey wipes.
A scintillation probe is used on survey meters like the Ludlum 3 for low energy photons (gamma-rays(^{125}I) and x-rays less than 40 keV). The efficiency of a low energy scintillation probe for the detection of ^{125}I is about 30-35%.

Ionization Chamber

Ionization chambers are suitable for measuring radiation dose rate or cumulative radiation dose. This instrument is not recommended for use in labs to detect contamination.

6. Radioactive Materials Incidents

A radioactive materials incident is any event that involves a loss of control over radioactive material and must be promptly reported to the EH&S Department (336-334-4357). Examples of these incidents are:

- Missing radioactive material;
- Unintended release of radioactive materials to the environment;
- Malfunction of a radiation device or radiation generating device;
- A spill of radioactive materials in excess of 1 mCi in an authorized area;
- Any spill of radioactive materials outside an authorized area (hallway, stairwell, etc.);
- Receipt of a contaminated package;
- Personal contamination;
- A fire or flood involving radioactive materials.

In general, response to radiation incidents should minimize any additional radiation exposures or contamination, notify others of the radiation hazard, secure the area, and contact the EH&S Department (336-334-4357).

All radiation users are responsible for reporting radiation incidents to the EH&S Department. The individual user and laboratory, through the Authorization Holder, are responsible for remediating a radiation incident. To ensure effective remediation and compliance with policy and regulation, the EH&S Department may direct the response and provide additional resources.

6.1 Response to a Spill

A spill of radioactive materials is when radioactive material contaminates an area or equipment not directly associated with the experiment. Proper preparation and training before work with radioactive materials should minimize both the risks and impacts of spills. Laboratories should be equipped with spill response supplies such as paper towels, cleaning agents, extra radioactive waste bags and gloves. The laboratory's initial response should follow guidance for the acronym **SPILL:**

Stop … working – get your thoughts together and don't panic
Presume … everything is contaminated until proven otherwise
Inform … others about the spill
Localize … the spilled material to contain the spill
Label … or cordon off the area to limit access

Cleanup of a radioactive materials spill shall begin immediately after the initial response listed above. To clean up a spill follow these instructions:

1. Presume the area is contaminated and prevent the spread of contamination.

2. Inform others of the situation and restrict access to the area.

3. Survey for personal contamination. Remove any contaminated clothing and wash contaminated skin with warm soapy water.

4. Call the EH&S Department if:
   - There is contamination on skin or suspected ingestion of material;
   - The spill is not in an authorized area;
   - More than 1 mCi is spilled in an authorized area;
   - The spill covers a large area or volume;
   - You are uncertain about how to proceed.

5. Wear proper protective equipment: gloves, laboratory coat, eye protection, booties (if available), and dosimetry (if assigned), before attempting spill cleanup.

6. Survey the contaminated area. Mark the perimeter of the spill and any isolated spots.

7. Thoroughly clean by wiping the contamination with dampened paper towels working from the perimeter towards the center of the spill. Household cleaning solutions are generally as effective as radiation specific products.

8. Dispose of contaminated cleaning materials in the appropriate radiation waste container.

9. Perform an extensive personal survey before leaving the immediate area. Take your time in surveying your hands, shoes, hair, face, lab coat and clothing.

10. Perform a wipe test to verify decontamination and repeat decontamination efforts until wipes show acceptable levels of contamination.

6.2 Airborne Releases

If you are working with radioactive materials that accidentally volatilize:

- Avoid inhaling contaminated air;
- Cover spill, if possible, to minimize airborne release;
- Turn on the hood if it is not already on;
- Shut off all general ventilation, heating and air-conditioning equipment that could transport contaminated air from the laboratory to other parts of the building;
- Evacuate the laboratory, closing the doors behind you;
- Secure the laboratory area and do not let anyone enter;
- Seal doors with tape if there could be significant leakage of airborne material into the corridor due to positive room pressure;
- Immediately contact the EH&S Department (336-344-4357).

6.3 Personal Contamination

Through the proper use of protective clothing and contamination control, the risks of skin contamination, ingestion, or inhalation are low. Due to the nature of the radioactive materials used, the radiation energy is usually deposited in a localized area and may result in high localized doses, especially to the skin. Any case of personal contamination requires prompt attention.

To remove skin contamination, gently wash with mild soap and lukewarm water. When washing, be careful not to redden or abrade the skin.

If you have reason to believe that someone may have inadvertently ingested or inhaled radioactive materials, contact the EH&S Department immediately for bioassay instructions.

6.4 Contaminated Clothing

Survey any potentially contaminated clothing and lab coats before removal from the lab. Clean any isolated contaminated areas on clothing by hand. If the contamination cannot be completely removed, the article can be disposed of as radioactive waste or held for decay. Contact the EH&S Department for guidance on holding items for decay.

7. Minimizing Exposures (ALARA Plan)

The University adheres to a goal of keeping radiation exposures to individuals or releases of radioactivity to the environment As Low As Reasonably Achievable (ALARA). This chapter sets forth the University's operational plan for keeping exposures ALARA. The plan is based on the Nuclear Regulatory Commission's definition of ALARA, which is maintaining exposures as far below the regulatory limits as practical with consideration of economics, state of technology, and other societal and socioeconomic considerations. To be effective, the plan seeks to establish goals which are accepted by all levels of management and those involved in the use of radioactive material.

7.1 Program Responsibilities

The Radiation Safety Officer (RSO) is responsible for executing the ALARA plan, as part of the Radiation Safety Program, with oversight from the Radiation Safety Committee (RSC). The Radiation Safety Program is audited on an annual basis by the RSO. Conformance with ALARA principles and goals are included in the audit, by review of operational procedures, authorization approvals, radiation incidents, radioactive material inventories, radiation dose records, and environmental release data.

To keep exposures ALARA, the Radiation Safety Program will:

- Follow ALARA guidelines in reviewing and approving proposed uses of radioactive materials and recommend modifications to experiments where indicated;
- Identify measures to achieve ALARA, such as use of protective devices, operational controls, and consideration of ALARA in designing experiments;
- Formulate written procedures where applicable in specific instances;
- Monitor and track all activities affecting potential exposures of workers and the public.
- Provide the training and guidance necessary to University management, the RSC, Authorized Users and University staff to meet the goals of the ALARA plan;
- Review records of radiation surveys, occupational exposures, and environmental releases at least quarterly to determine compliance with ALARA and good practice principles.

Goals and Action Levels

Table 1 identifies the University's exposure goals and action levels, at which prescribed actions are to be taken by the EH&S Department. Should a measured value exceed Level I, the EH&S Department will review the circumstances and, at its discretion, take additional steps to investigate and/or take action to reduce the value. Any value which exceeds Level II requires investigation and efforts to reduce further exposures with consideration of total cost and scientific impact. Reports of all investigations shall be presented, along with an exposure/release history, to the Radiation Safety Committee.

Table 1

ALARA Plan Goals and Investigation Levels

	Regulatory Limit	Goal	Investigation Level I (mrem per calendar quarter)	Investigation Level II (mrem per calendar quarter)
Whole Body[a]	5,000 mrem/y	500 mrem/y	125	375
Lens of the Eye[a]	15,000 mrem/y	1,500 mrem/y	375	1125
Skin and/or Extremity[a]	50,000 mrem/y	5,000 mrem/y	1250	3750
Minors (whole body) [a]	100 mrem/y	50 mrem/y	10	30
Embryo/Fetus[a]	500 mrem in the 9 month gestation period	50 mrem in the 9 month gestation period	20	60
Member of Public on site (NRC) [c]	100 mrem/y whole body exposure	20 mrem/year	5[b]	15[b]
Member of Public off site (EPA)[c]	10 mrem/y with less than 3 mrem due to radioiodine from airborne releases	3 mrem/year	1[b]	3[b]
Environmental Releases[d]	10 CFR 20 Appendix B Table 2	10% of 10 CFR 20 Appendix B averaged over one year at the boundary; or listed value at the stack.	10% of 10 CFR 20 Appendix B averaged over the calendar quarter at the boundary; or listed value at the stack.	30% of 10 CFR 20 Appendix B averaged over the calendar quarter at the boundary; or listed value at the stack.

[a] Limits for an occupationally exposed individual.
[b] Mathematical models are used to calculate dose based on releases to the environment.
[c] EPA limits apply to airborne exposure to a member of the public, while NRC limits apply to all sources of radiation from the institution to the highest exposed member of the public.
[d] Values based on a total effective dose equivalent of 50 mrem per year.

7.2 User Responsibilities

Individuals using radioactive materials and operating radiation producing equipment are responsible for limiting exposure to themselves, the community and the environment. This can be accomplished by following the steps identified in Section 7 (Safe Handling of Radioactive Materials), outlining the appropriate planning and use practices to keep exposures ALARA.

The guiding principle to limiting radiation exposure to individuals is to control TIME, DISTANCE, and SHIELDING.

- Reduce TIME spent handling or near radioactive materials by performing a "dry run", using stable or a small amount of radioactive material, to perfect your technique and identify potential problems.
- Increase DISTANCE by using tongs or other handling tools.
- Use appropriate SHIELDING when working with high energy sources.

7.3 Shielding

Shielding may be necessary for working with or storing radioactive materials. Sources should be stored in their original container, which typically contain appropriate shielding material. Once removed from the original container or vial, a shielded box may be necessary to store the material. Waste containers of high energy sources may also require shielding to reduce external exposure rates to acceptable levels.

The type of shielding media must be considered before use. Do not use lead with high energy beta radiation (e.g. ^{32}P) because it will cause secondary x-ray radiation, use low atomic number materials such as plastics, Lucite, or Plexiglas. For gammas (^{125}I), use lead foil or thin lead sheets. Place the radioactive material close to the shield to maximize the "shadow area" cast by the shield and survey the area to ensure proper placement.

7.4 External Dosimetry

Radiation dosimeters are devices worn by a person or placed in an area to measure external radiation exposures. Radioactive material users may be required to wear a whole body dosimeter or a ring dosimeter, to monitor their external exposure to energetic beta, gamma or X-ray radiation. The EH&S Department coordinates the dosimetry program, which uses dosimetry products from a vendor accredited by the National Voluntary Laboratory Accreditation Program, (NVLAP). Radioactive material users are monitored and the results are sent to the Authorization Holder. Dosimetry results are available from the Authorization Holder and the Department of Environmental Health and Safety.

DHHS and UNCG policy require appropriate dosimetry be provided to individuals likely to receive 10 percent of the annual occupational exposure limits (Table 1). Dosimetry will also be assigned to individuals who have a declared or planned pregnancy or meet issuance criteria as determined by the EH&S Department. Issuance criteria will be determined by the proposed use, as indicated on the user registration form and authorized protocols, and will be reevaluated with changes to registration forms, protocols, personnel monitoring results, and high dose investigations.

Individuals working solely with low energy beta emitters (^{3}H and ^{14}C) generally do not require dosimetry. Individuals working any high-energy beta (e.g. ^{32}P), x- or gamma ray emitters (^{125}I and ^{51}Cr) will be assigned whole body dosimetry. Finger badges will also be assigned to individuals handling high energy beta emitters or operating analytical x-ray equipment.

Proper Dosimetry Use

A radiation user is assigned a temporary dosimeter at the successful completion of the required training program. Each dosimeter is assigned to an individual; do not wear a dosimeter assigned to another person. The dosimeter must be worn whenever you are in the laboratory, working with or around radiation sources.

Wear the whole body dosimeter on your torso, positioned so that it is closest to the source of radiation. Wearing it on the chest or at bench level are two suitable locations. It should be worn outside the lab coat; use caution to prevent contamination.

Wear the TLD ring INSIDE the glove, on the hand used most often to handle radioactive materials, with the text side facing the inside of the palm.

When not in use, dosimeters should be stored away from sources of radiation or with control dosimeters.

7.5 Dosimetry Records

Radiation dosimetry results are first reviewed by the vendor when the dosimeter is processed and then by the EH&S Department within about one week of receipt. Action levels for high dose review and investigation are outlined in Table 1.

A report is typically mailed to the laboratory with the next shipment of new dosimetry. The dosimetry coordinator should make this information available to the laboratory staff. If dosimetry reports are posted, personal information such as name, Social Security number or birth date should be removed prior to posting.

7.6 Internal Dosimetry (Bioassay)

Bioassays are measurements of radioactivity in the body and are used to assess internal radiation dose from ingestion, inhalation or absorption. Individuals working with large amounts of volatile radionuclides may be required to participate in the bioassay program. Bioassays may also be ordered by the EH&S Department following an incident, unusual event, or procedure that may result in uptake.

A bioassay will be required for an individual working with more than 100 mCi of ^{3}H within a thirty day period. A urine sample shall be submitted to the EH&S Department for urinalysis within 10 days of exceeding the 100 mCi threshold. Please make arrangements with the EH&S Department before beginning work.

A thyroid bioassay may be required for work involving more than 1 mCi of radioactive iodine at one time. A thyroid count must be conducted between 24 and 72 hours after working with the following quantities:

1. Processes in open room or bench with possible escape of iodine (a situation strongly discouraged):

   Volatile or dispersible…….....1 mCi
   Bound to non-volatile agent……..10 mCi

2. Processes with possible escape of iodine carried out within a fume hood of adequate design, face velocity, and performance reliability:

   Volatile or dispersible……..….10 mCi
   Bound to non-volatile agent…….....100 mCi

3. Processes carried out within glove boxes, ordinarily closed, but with possible release of iodine from process and occasional exposure to contaminated box and box leakage:

   Volatile or dispersible…….....100 mCi
   Bound to non-volatile agent……..1000 mCi

7.7 Pregnant or Potentially Pregnant Radiation Users

DHHS has established a 500 mrem radiation dose limit to the embryo/fetus during the nine-month gestation period for those who declare their pregnancy in writing to the EH&S Department. This declaration may be made in confidence. When a person notifies the EH&S Department that they are pregnant or trying to become pregnant, the EH&S Department will provide an appropriate monitoring program. At the University, this policy applies to males as well as females who are either pregnant or trying to become pregnant.

8. Radioactive Materials in Experimental Animals

Work with radioactivity in an animal is jointly managed by the Institutional Animal Care and Use Committee (IACUC) and the Radiation Safety Committee (RSC). All users need to obtain authorization from both IACUC and RSC for the particular protocol before research begins. The Authorization Holder is responsible for ensuring radiation safety, conducting radiation surveys and radioactive waste disposal. Through the authorization process, the Authorization Holder will address and resolve animal care and posting requirements and the training, monitoring and protective clothing for involved staff.

8.1 Animal Housing

The Institutional Animal Care and Use Committee requires that animals be housed in central facilities. As a result, this requires prior approval for any animal that would be housed outside of the central facility. This prior approval will include detailed procedures for animal care and will address waste disposal and cage decontamination or replacement. When an animal is housed in the laboratory, the Authorization Holder is responsible for comprehensive care of the animal as well as all radiation safety aspects.

8.2 Special Radiation Considerations

Use trays lined with absorbent material when injecting animals with radioactive materials.

Label all cages housing animals injected with radioactive materials. Labeling must include an appropriate colored universal radiation symbol, the words “Caution – Radioactive Materials”, the radionuclide, activity, date injected, Authorization Holder name and phone number. Segregate these cages from those of other animals.

Provide adequate ventilation in areas where animals are kept if they have been injected with radioactive material that may be volatilized and dispersed following excretion or exhalation.

Treat all cages, equipment used and rooms housing the animals as contaminated until a recorded survey has demonstrated otherwise.

Provide animal handlers with written instructions on radiation control measures and safety precautions, and animal bedding and excreta handling requirements. Bedding and excreta are to be collected as radioactive waste. Contact the EH&S Department for waste packaging information.

Do not discard needles directly into radioactive waste containers. Collect needles as biohazard/sharps and post the waste container as radioactive.

Place animal carcasses in heavy black plastic bags, at least 4 mil thick, labeled to indicate the radionuclide, quantity, Authorization Holder, date and department, and store in a secured freezer in a room that is listed on the Authorization before disposal through the EH&S.

9. Radioactive Waste

Waste disposal is very expensive and a strictly regulated process. Regulation involves not only the DHHS Radiation Protection Section, which issues the University's License, but the U.S. Department of Transportation, and the U.S. Environmental Protection Agency. The storage and handling of radioactive wastes are also of concern to the Governing Boards of the University, the local Fire Department and members of the public who live near University waste handling and storage facilities. To ensure compliance with regulations and to minimize releases of radioactivity to the environment, the University requires that users of radioactive materials follow very carefully the procedures prescribed in this chapter for packaging, labeling and processing of waste materials.

9.1 General Responsibilities

By careful experimental design, following appropriate working procedures and cleaning contaminated materials, it is often possible to dramatically reduce the volume of waste required to be disposed of as radioactive. Monitor waste material and dispose of only the contaminated items as radioactive. Use short-lived radioactive materials whenever possible. Doing so will systematically reduce waste disposal costs and make it easier to manage the laboratory radiation safety program.

The costs of disposal methods vary widely. Disposal at a commercial low-level radioactive waste disposal facility is by far the most expensive option. Where possible, segregate and package waste so that alternative methods can be used. Waste shall be separated by type and half-life. Segregate "short-lived" waste (half-life <180 days) for placement in the University decay-in-storage facility where the waste will be stored until the radioactivity is insignificant.

9.2 Managing Non-Radiological Hazards

To meet requirements of various state and federal laws, the Department of Environmental Health and Safety will not accept radioactive waste that contains hazardous wastes, untreated biological pathogenic or infectious wastes or improperly packaged sharps.

The Department of Environmental Health and Safety does not normally approve of procedures that generate mixed chemical and radioactive waste. If it is possible that an experiment will generate an EPA classified hazardous waste, carcinogen, reproductive toxin or other toxic material, contact the Department of Environmental Health and Safety before carrying an experiment to determine proper waste disposal options.

Treat wastes containing hazardous biological, pathogenic or infectious materials with a chemical disinfectant, such as bleach, or autoclave to inactivate the hazard. For more information contact the Department of Environmental Health and Safety. Consider volatility issues before autoclaving radioactive waste, because of the potential for contaminating equipment and releasing radioactive vapors.

Sharps and broken glass must to be packaged in a RSO-approved sharps container prior to disposal in a dry waste container.

Needles contaminated with radioactive materials must be properly treated for any biological hazard and packaged in an approved needle container using a method approved by the Department of Environmental Health and Safety. Place the needle container in a clear plastic bag and place in the dry/solid waste container.

9.3 Preparing Radioactive Waste

All radioactive waste containers must be labeled with an appropriately colored universal radiation symbol and the words "Caution – Radioactive Materials". Dry and Scintillation vial waste containers must also be posted with a "Do Not Empty" sign.

A waste log (Appendix A) must be attached or posted near the container. The waste form shall identify the Authorization Holder, radionuclide(s) and activity of all waste placed in the container. If not attached to the container, the waste form shall also include information to identify the corresponding waste container. When the exact activity of material placed in the container is not known, a close estimate may be recorded.

Where necessary, use appropriate shielding around the container to reduce personnel exposure as much as possible. If the dose rate measured at one foot from the container exceeds 2 mrem/hr, the addition of shielding or other corrective action must be taken immediately, to reduce the dose rate to acceptable levels.

Complete a Radioactive Waste Removal Form (Appendix A) for each radioactive waste container when ready for pick-up by EH&S. Send the form to the EH&S Department and then attach it to the container for pick-up.

9.4 Solid Radioactive Waste

Collect dry solid waste (paper, plastic, gloves, etc.) in an approved waste container lined with a sturdy plastic bag. No free liquids may be placed in a dry waste container. Residual liquids in tubes and vials, up to a few milliliters, may be absorbed by a pad or paper towel and placed in the dry waste. Sources vials with sufficiently absorbed liquid may be placed in the container if the resulting dose rate measured one foot from the outside of the waste container will not exceed 2 mrem/hr.

Do not place lead in dry waste containers. See the lead waste section below for guidance.

Dry waste containers must be covered with a lid when waste is not actively being entered.

Dry solid Iodine or other volatile radioactive waste materials shall be collected in separate plastic bags. The bags shall be sealed after each experiment and then placed in the dry waste container.

9.5 Liquid Radioactive Waste

Collect liquid radioactive waste in an EH&S approved container appropriate for any chemical hazards present. Segregate waste by half-life (<180 days = "short-lived"). Liquid waste containers must have a lid secured when waste is not being actively added and shall be stored with secondary containment. A radioactive waste tag shall be attached to all liquid waste containers, identifying the Authorization Holder and radionuclide(s).

Absorb nonflammable, pH neutral (5.5 to 9.5) aqueous radioactive wastes, other than liquid scintillation media in EH&S approved containers.

Place organic liquid in non-breakable containers appropriate for the material without absorbent. Disposal instructions for these wastes are determined on a case-by-case basis by the EH&S Department and are usually identified in the experimental review process. If beginning a new of different experiment that will generate organic or hazardous materials in radioactive wastes consult the EH&S Department before starting the experiment.

Minimize volatility of liquid radioiodine wastes by adding a sodium metabisulfite solution (0.1M sodium hydroxide, 0.1 M sodium thiosulfate, and 0.1 M sodium iodide).

Store any flammable liquid radioactive waste in a flammable materials storage cabinet; contact the EH&S Department for disposal instructions.

9.6 Liquid Scintillation Vials

Use only high flashpoint (above 141° F), nontoxic, nonhazardous liquids scintillation media.

Segregate scintillation vials by radionuclide (^{3}H and ^{14}C may be placed in one bag). For vials that contain only ^{3}H and ^{14}C, segregate those with an activity of less than 0.05 μCi (111,000 DPM) per milliliter.

Tightly cap scintillation vials and pack in vial-boxes that are sealed in a 4 mil plastic bag or double bag in 4 mil plastic bags with no more than 200 full sized or 400 mini-vials. Collect bags in an EH&S approved drum and record the estimated activity on the waste form.

Bulk scintillation fluids, such as that from flow-through counters, may be collected in one gallon or smaller plastic or glass containers.

List the manufacturer and product name of the liquid scintillation media on the radioactive waste removal form.

9.7 Uranium and Thorium Waste

While uranium and thorium may be obtained as unlicensed radioactive material, they may be required to be disposed of as radioactive waste. Contact EH&S to determine disposal procedures.

9.8 Radioactive Biological Waste

Biological waste includes animal and animal-related wastes from experiments involving radioactive materials. This waste may include carcasses, animal bedding, and specimens contained in vials or other containers. This waste may not contain active biological hazards or sharps, see the Regulated Medical Waste Policy for treatment methods.

Place carcasses and tissues in 4 mil opaque black plastic bags. Remove all tissue samples from containers such as a plastic bottle or test-tube before disposing as radioactive waste. Very small amounts of paper, plastic and other non-animal wastes may be placed into this bag. Place animal bedding in clear 4 mil plastic bags.

Label bags with the radionuclide, activity and concentration per gram of total animal/sample weight, Authorization Holder, and date, and store in a secured freezer in a room that is listed on the Authorization before pick-up by the EH&S Department.

9.9 Sewer Disposal

Radioactive material may be disposed of only in approved sinks, and in quantities below the daily sink disposal limits in Table 2. Dispose of any unused radioactive chemicals and/or original source material through the EH&S Department if the material is still radioactive.

For disposal of trace amounts and washings, use a sink approved and registered by the EH&S for radioactive waste disposal that is posted with a "Caution-Radioactive Material" sign. Do not discharge more material into the sink each day than the amounts given in Table 2, unless otherwise authorized by the EH&S Department. Flush the sink thoroughly with water, continuing until the material is washed from the sink.

Record each such disposal on a Sewer Disposal Log (Appendix A) that is posted near the sink. Record the date of each disposal, a reasonable estimate of the maximum activity discharged and the initials of the individual making the disposal. The EH&S Department will collect the sink disposal logs and compile records on releases to the environment, as required by Federal, Local and State regulations.

Table 2

Daily Sewer Disposal Limits (µCi)

^{3}H	1,000	^{45}Ca	10
^{14}C	100	^{51}Cr	1000
^{32}P	10	^{55}Fe	100
^{33}P	50	^{125}I	1
^{35}S	100	^{131}I	1

Use Sewer disposal only for material that is **readily soluble** in water and not hazardous. There are many approaches that may be used to determine a chemical compound's solubility in water.

If the chemical form of all materials contained in the liquid waste is known, it is possible to use either a solubility class or formal solubility to determine if the material is soluble in water.

9.10 Lead Waste

Package lead separately for pick-up by the EH&S Department. Conduct a wipe test of lead waste to ensure that it is free of contamination and attach results to the container prior to submitting the waste pick-up request to EH&S. If contamination cannot be removed from lead, contact EH&S for guidance on disposal.

10. Laboratory Record Requirements

The Authorization Holder is required to maintain laboratory specific records and to make those readily available to laboratory staff, the EH&S Department, and regulatory inspectors. These records include:

Authorization
The authorization issued by the Radiation Safety Committee (via EH&S) shall be available in the laboratory. The authorization identifies the authorized use areas, approved protocols, nuclides, and possession limits.

Inventory
The Authorized User is responsible for maintaining a current inventory at all times. Both Daily Use Logs (Appendix A) and monthly inventory records shall be kept up to date and on file in the laboratory. Daily Use Logs shall identify any use, transfer, decay, or disposal of radioactive materials. Monthly inventory statements, summarizing monthly inventory changes for each source, shall be recorded for each calendar month where entries are made on the Daily Use Log. Inventory records must be kept on file for three years after the final disposal or transfer date.

Surveys
Records of all required wipe tests and external radiation surveys shall be kept on file for three years. Wipe tests shall be conducted and documented within 7 days of use of unsealed radioactive materials. Meter surveys shall be conducted and documented within seven days of use of any gamma or high energy beta emitter. See section 5 for details.

Waste
Accurate waste forms must be maintained near each waste container until picked up by EH&S. The waste form must include the name of the Authorization Holder and a log of all material entered in the container. The log shall include the date, nuclide and a reasonable estimation of activity for each entry. A unique container identifier may also be necessary where multiple containers of similar waste are present.

Sink Disposal Log
A log sheet shall be posted at each sink authorized for sewer disposal. The date, nuclide, and activity shall be recorded for each disposal. The log sheet shall remain posted until collected by EH&S. Filled log sheets may be archived in the radiation safety notebook.

Iodination Logs
All iodinations and associated surveys must be recorded on an Iodination Log (Appendix A) posted or filed in the lab. These records must be kept by the Authorized User for three years.

Personnel Monitoring
Dosimetry and bioassay records will be provided to the Authorization Holder and dosimetry coordinator, who will make them available to laboratory staff. The laboratory should keep these records for one year. Original copies are retained by the EH&S Department.

11. X-ray Producing Equipment

All radiation generating devices, such as analytical x-ray and bone densitometer units must be registered with and approved by the EH&S Department prior to acquisition. The device is registered by obtaining an Authorization to acquire and use radiation producing equipment, issued by the Radiation Safety Committee (via the EH&S Department). This Authorization specifies the Authorized User, usually a Faculty Member, use restrictions and approved operators. Regulations vary according to the type of X-ray equipment. The EH&S Department will classify the equipment upon receipt of the application for Authorization, to determine the regulatory and safety requirements. Significant compliance measures, facility review and planning may be necessary and should be factored into timely submission of the application for Authorization of the new device.

All operators, except for electron microscope users, must submit a Radiation Worker Registration Form (Appendix A) to the EH&S Department and receive initial training before using any x-ray equipment. The Authorization Holder is responsible for annual refresher training for all current operators.

11.1 Analytical X-ray Machines

X-ray diffraction devices use a high intensity x-ray beam to assess the atomic and molecular composition of a material. To ensure personal safety and regulatory compliance, this section outlines the safety program for analytical x-ray machines. X-ray equipment may vary and a device specific safety program may be necessary. The EH&S Department will determine the appropriate safety and compliance measures at the time of Authorization.

Emergency Procedure

If there is a suspected or actual case of accidental radiation exposure, turnoff the system power and notify the EH&S Department IMMEDIATELY (336) 334-4357. Some exposures may require monitoring by medical professionals.

Exposure Hazard

The radiation exposure rate from the primary beam can be up to 40,000 Roentgen per minute. Direct exposure to the primary beam can cause severe injury. Proper shielding, interlocks, and use procedures should prevent exposure to the primary beam. With such a high exposure rate, the hazard is not limited to the primary beam, but can also be related to leakage or scatter radiation. Use shutters and collimators to reduce the beam cross-section and secure unused ports. X-ray machines should not be modified without the authorization of the EH&S Department.

Biological Effects of Acute Radiation Exposures as Related to X-ray Systems

With a properly functioning machine, there is little risk of radiation exposure. However, direct exposure to the high intensity beam can cause severe injury and one should know the signs of an acute exposure to a localized area of the human body. Be aware that these effects can be caused by contact with the beam for only a fraction of a second. The most common effect from a large radiation exposure from an x-ray device is reddening of the skin (erythema). With a dose of a few hundred rem the superficial layers of the skin are damaged and the skin will redden in a fashion similar to but more complex than a sunburn. The erythema effect will most often reverse itself within a few weeks. Exposure to the eye may cause conjunctivitis (inflammation of the eye). It is possible that chronic exposures may lead to cataract formation.

Dosimetry Requirements

All equipment operators are required to wear ring and whole body dosimeters.

Training

All users must complete the EH&S Department Radiation Safety Training and must also be provided specific written instructions by the Authorization Holder before using the equipment. These instructions include machine specific work practices and safety precautions.

Operating Guidelines

To ensure the safety of users and visitors of x-ray equipment, follow the manufacturer's recommended safe use practices. A radiation survey should be done whenever a new sample is placed in the beam, experimental setup is changed or equipment is moved, reconfigured or serviced. Securely close any unused tube ports to prevent leakage or scatter radiation.

Sample Changing

Ensure the x-ray beam is inactive by using a radiation detector. Use the shutter to stop x-rays. Verify shutter activation and that the shutter indicator is properly reporting shutter status.

Beam Alignment

- Only a trained and qualified user should do an alignment.
- Wear a finger dosimeter.
- Whenever available, use electronic alignment.
- Use long handles on the fluorescent alignment screens.
- If safety locks must be bypassed, first gain EH&S Department approval and then post a sign indicating the safety switch status. Re-engage the safety switch as soon as possible.
- Use the lowest power settings possible for beam alignment procedures.

Posting Requirements

The following documents or labels shall be posted as indicated:

- Analytical x-ray Emergency Procedures near the operator controls;
- DHHS Notice to Employees shall be posted in a conspicuous location;
- A label bearing the words "Caution Radiation This Equipment Produces Radiation When Energized" near the tube activation switch;
- A sign "Caution High-Intensity x-ray Beam," next to each tube-head. The sign must be clearly visible to any person operating or aligning the unit or changing a sample;
- A posting on the exterior side of the room's doors indicating the presence of x-ray producing equipment such that visitors to the lab will see the sign.

Indicators & Safety Devices

All x-ray machines will contain an operational and clearly visible indicator of an active x-ray beam near the x-ray tube.

Operational interlocks and safety devices will be provided to ensure that the primary x-ray beam cannot be interrupted by any portion of an individual's body or extremities or by machine equipment under any operating condition. If the beam is interrupted, this interlock will shut off the primary beam.

Interlocks and safety devices may not be altered without the written authorization of the EH&S Department. Approved temporary modifications must be terminated as soon as possible, specified in writing and posted near the x-ray machine tube and operators console.

11.2 Bone Densitometers

Dual-energy x-ray absorptiometry (DEXA) densitometers use a low level x-ray source to assess bone and tissue composition. Typical equipment poses a minimal radiation exposure risk to subjects and operators, and numerous regulations may apply. A device specific safety program shall be developed, detailing the administrative and engineering controls necessary to ensure safe and compliant operation. The safety program may include the following topics:

- Operator registration and training;
- Access controls;
- Posting & labeling;
- Safety precautions;
- Operating procedures;
- Technique charts;
- Recordkeeping;
- Radiation dose minimization for subjects, personnel, and the public;
- Dosimetry;

11.3 Cabinet X-ray Systems

A cabinet x-ray system is a x-ray system where the x-ray tube is enclosed in a structure that contains the irradiated material, provides radiation shielding, and excludes people.

Since cabinet x-ray systems are designed to exclude people, they are exempt from many of the regulations that apply to other x-ray devices. However, these devices must be registered with the EH&S Department through an Authorization and have a written safety program, approved by the EH&S Department. The safety program should include the following topics:

- User training;
- Access control;
- Posting & labeling
- Radiation hazards associated with the x-ray system;
- Safety precautions;
- Operating, maintenance, and repair procedures;
- Emergency procedures;
- Recordkeeping;
- Dosimetry.

General safety protocols for cabinet X-ray systems can be found in Appendix C.

11.4 Electron Microscope Systems

An electron microscope system is an x-ray system where the x-ray tube is enclosed in a structure that contains the irradiated material, provides radiation shielding, and excludes people.

Since cabinet x-ray systems are designed to exclude people, they are exempt from many of the regulations that apply to other x-ray devices. However, these devices must be registered with the EH&S Department through an Authorization and have a written safety program, approved by the EH&S Department. The safety program should include the following topics:

- User training;
- Access control;
- Posting & labeling
- Safety precautions;
- Operating, maintenance, and repair procedures;
- Emergency procedures;
- Recordkeeping;
- Dosimetry.

General safety protocols for electron microscope systems can be found in Appendix D.

Glossary

Activity – The rate of disintegration (transformation) or decay of radioactive material. The units of activity are curie (Ci) and the Becquerel (Bq).

Agreement State – Any state with which the U.S. Nuclear Regulatory Commission has entered into an effective agreement under subsection 274b. of the Atomic Energy Act of 1954, as amended. Under the agreement, the state regulates the use of by-product, source, and small quantities of special nuclear material within said state.

Airborne Radioactive Material – Radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists vapors, or gases in any room, enclosure, or operating area.

ALARA – Acronym for "As Low As Reasonably Achievable". Making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical, consistent with the purpose for which the licensed activity is undertaken. It takes into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, societal and socioeconomic considerations, and in relation to utilization of radioactive materials and licensed materials in the public interest. See ALARA Plan for specific University details.

Alpha particle – A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus, with a mass number of 4 and a charge of +2.

Annual Limit on Intake (ALI) – Annual intake of a given radionuclide by "Reference Man" which would result in either a committed effective dose equivalent of 5 rems or a committed dose equivalent of 50 rems to an organ or tissue.

Attenuation – The process by which radiation is reduced in intensity when passing through some material. It is the combination of absorption and scattering processes.

Ancillary Worker – Any individual who works in support of the laboratory operations and does not work with radioactive materials directly.

Authorization – Official document issued by the Radiation Safety Committee to the authorized user stating scope of the authorization to use radioactive materials and conditions of use.

Authorization Holder – The individual to whom the Authorization is issued by the Radiation Safety Committee.

Authorized User – The individual authorized by the Radiation Safety Committee to use and supervise the use of radioactive materials. Typically, the Authorized User is a senior investigator or faculty member who has the primary scientific, financial, and legal responsibility for a research program. The Authorized User may use the authorized radiation sources directly or, with the approval of the Radiation Safety Committee, may delegate the operational

responsibilities to a Registered User. The Authorized User has primary responsibility for radiation safety in facilities under his or her control.

Background Radiation – Radiation from cosmic sources; naturally occurring radioactive materials, including radon and fallout from nuclear weapons tests.

Beta particle – High speed electrons, which are emitted from the nuclei of radioactive atoms during radioactive decay, as a result of the transformation of a neutron into a proton. They can be stopped by a thin (thickness varies for different radionuclides) sheet of plastic or glass.

Becquerel – A unit, in the International System of Units (SI), of measurement of activity equal to one decay per second.

Bioassay – The determination of kinds, quantities, or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct counting (in vivo) or by analysis and evaluation of materials excreted or removed from the body.

Biological Half Life – The time that is required by an organism to eliminate half the amount of a substance that has entered it.

Bremstrahlung – X-rays produced when a charged particle loses energy in interactions with heavy nuclei when moving through matter.

Calibration – The check or correction of the accuracy of a measuring instrument to assure proper operational characteristics.

Charged Particle – An elementary particle or ion which carries a positive or negative electric charge.

Committed Effective Dose Equivalent – The dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the 50 year period following intake.

Contamination – The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel. Can either be fixed or removable.

Controlled Area – An area where access is controlled to limit potential exposure to members of the public. A controlled area will be established for any occupied space where the exposure may exceed 2 millirem in any one hour.

Counter – A general term used for a radiation detection instruments, survey meter, or a liquid scintillation counter (LSC) that detects and measures radiation. The signals (needle blip and audio beep) represent detected ionization events called counts.

***CPM (Counts Per Minute)* –** A commonly used measure of radioactivity from particle emitters; since a detection instrument cannot operate at 100% efficiency, the CPM found will be less than the actual disintegrations per minute (DPM).

***Critical Organ* –** The organ receiving the highest dose or highest amount of a particular nuclide that results in the greatest damage to the body as a result of an intake.

***Cumulative Dose* –** The total dose resulting from repeated exposures of radiation to the same region, or to the whole body, over a period of time.

***Curie (Ci)* –** The basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of radium. Named for Marie and Pierre Curie, who discovered radium in 1898.

***Decay, Radioactive* –** The decrease in the amount of any radioactive material with the passage of time, due to the spontaneous emission from the atomic nuclei of either alpha or beta particles, or gamma rays.

***Declared Pregnant Worker* –** A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

***Decontamination* –** The reduction or removal of contaminating radioactive material from a structure, area, object, or person.

***Deep Dose Equivalent* –** A term that applies to external whole-body exposure, and is the dose equivalent at a tissue depth of 1 cm.

***Deregulated Wastes* –** Wastes that have been designated by the EH&S Department as eligible for handling and disposal as nonradioactive, according to the regulations of the NCDHHS Radiation Protection Section.

***Detector* –** A material or device that is sensitive to radiation and can produce a signal suitable for measurement or analysis.

***Disintegration* –** See decay, radioactive.

***Dose* –** A generic term referring to the amount of radiation received by a biological organism.

***Dose Equivalent* –** The product of the absorbed dose in tissue, quality factor, and other modifying factors at the location of interest. The units are mrem.

***Dose Rate* –** The ionizing radiation dose delivered per unit time, such as mrem/hour.

***Dosimeter* –** A portable instrument for measuring the total accumulated exposure to ionizing radiation.

***DPM (Disintegrations per Minute)* –** The number of radioactive disintegrations per minute; there are 2.2E6 disintegrations per minute in a microCurie (μCi).

***Effective Dose Equivalent* –** The sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated.

***Effective Half-Life* –** The time required for the amount of a radioactive element deposited in a living organism to be reduced by 50% from the combined removal mechanisms of radioactive decay and biological elimination.

***Embryo/Fetus* –** The developing human organism from conception until the time of birth. More specifically; embryo: 2 weeks (implantation) – 8 weeks; fetus: 8 weeks – term.

***Exposure* –** 1) A measure of the ionization produced in air by x or gamma radiation. The unit of exposure is the Roentgen(R). 2) Being exposed to ionizing radiation or to radioactive material.

***Exposure Rate* –** The amount of ionization in air caused by x-ray or gamma ray radiation per unit time; unit of measurement is the Roentgen per unit time (R/hr).

***External Dose* –** The portion of the dose equivalent received from radiation sources outside the body.

***Extremity* –** Arm below the elbow and the leg below the knee.

***Eye Dose Equivalent* –** Applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 cm.

***Gamma Ray* –** Relatively short wavelength electromagnetic radiation released from the nucleus of an atom.

***Geiger-Mueller Counter (GM)* –** A radiation detection instrument that can detect alpha, beta and gamma radiation; response is not energy dependent.

***Half-life* –** The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also referred to as the physical half-life.

***Half Value Layer* –** The thickness of any given absorber (shield) that will reduce the intensity of incident radiation to one half of its initial value.

***Health Physics* –** The science concerned with recognition, evaluation, and control of health hazards from non-ionizing and ionizing radiation.

High Radiation Area – An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 100 mrem in 1 hour at 30 cm from the radiation source or from any surface that the radiation penetrates.

Intake – Quantity of material introduced into the body by inhalation, ingestion, or through the skin.

Internal Dose – That portion of the dose equivalent received from radioactive material taken into the body.

Ionization – The process of adding or removing one or more electrons from atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or radiation can cause ionization.

Ionization Chamber – An instrument that detects and measures ionizing radiation by measuring the electrical current that flows when radiation ionizes gas in a chamber, making the gas a conductor of electricity.

Ionizing Radiation – Any radiation capable of displacing electrons from atoms or molecules, producing ions. Examples: alpha, beta, gamma, x-rays, neutrons high-speed electrons, high-speed protons, and other particles capable of producing ions.. High doses may produce severe skin or tissue damage.

Irradiation – Exposure to radiation.

Isotope – One of two or more atoms with the same number of protons, but different number of neutrons, in their nuclei. Example: 12C, 13C, and 14C are isotopes of the same element. Isotopes have very nearly the same chemical properties, but often different physical properties (12C and 13C are stable, while 14C is radioactive).

Limits – The permissible upper bounds of radiation doses.

Liquid Scintillation Counting – A method of determining activity of a radioactive sample using a liquid Fluor and a means of detecting the scintillation resulting from the interaction of radiation with the Fluor.

NaI (Sodium Iodide) Detector – A detector which combines a scintillation crystal (produces light when struck by ionizing radiation), a photomultiplier tube, and associated electronic circuits for counting light emissions produced in the crystal (NaI) by ionizing radiation. A NaI scintillation probe with a ratemeter can be used for detection of gamma and x-rays.

Nuclide – A general term referring to all known isotopes, both stable (~279) and unstable (~5000), of the chemical elements.

Occupational Dose – The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material. This

does not include dose received from background radiation, as a patient from medical procedures, from voluntary participation in medical research programs, or as a member of the general public.

Personnel Monitoring – The determination of the degree of radioactive contamination on individuals using survey meters, or the determination of radiation dosage received by means of dosimetry devices.

Physical Half Life – The time required for a radioisotope to reduce activity by half.

Pig – A container (usually lead) used to ship or store radioactive materials. The thick walls protect the person handling the container from radiation. Large containers are usually called casks.

Potentially Radioactive Materials – Any materials that could become radioactively contaminated as a result of laboratory work.

Proportional Counter – A radiation detection instrument in which an electronic system receives pulses that are proportional to the number of ions formed in a gas-filled tube/probe by ionizing radiation.

Quality Factor – The modifying factor that is used to derive dose equivalent from the absorbed dose. They vary for different radiation types and reflect the degree of biological effect.

Quarter – A period of time equal to one-fourth of the year observed by the licensee (approx. 13 consecutive weeks). Providing that the beginning of the first quarter in a year coincides with the starting date of the year and that no day is omitted or duplicated in consecutive quarters.

Rad – The special unit of absorbed dose. One rad is equivalent to 100 ergs/gram or 0.01 J/kg.

Radioactive Contamination – The presence of radioactive material in any place where it is not supposed to be.

Radiation – Alpha particles, beta particles, gamma rays, x-rays, neutrons, high speed electrons, high speed protons, and other charged particles capable of producing ions. Radiation, as used in this context, does not include non-ionizing radiation, such as radio waves, microwaves, or visible, infrared, or ultraviolet light.

Radiation Area – An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5 mrem in 1 hour at 30 cm from the radiation source or from any surface that the radiation penetrates.

Radiation Detection Instrument – A device that detects and records the characteristics of ionizing radiation.

Radiation Generating Device or machine **(RGD) –** Any device capable of producing radiation except those which produce radiation only from radioactive material.

Radiation Safety Committee – The University Committee that is responsible for the oversight of and for setting the policies of the Radiation Safety Program.

Radiation Safety Officer – The individual responsible for implementing the policies and procedures of the Radiation Safety Committee and for the day-to-day operation of the Radiation Safety Program.

Radiation Shielding – Reduction of radiation by placing a shield of absorbing material between any radioactive source and a person, work area, or radiation sensitive device.

Radiation Source – Usually a manmade sealed source of radiation used in teletherapy, radiography, as a power source for batteries, calibration, or in various industrial gauges. Machines such as accelerators, radioisotope generators, and natural radionuclides may be considered sources.

Radiation Standards – Exposure standards, permissible concentrations, rules for safe handling, regulations for transportation, regulations for industrial control of radiation and control of radioactive material by legislative means.

Radiation Warning Symbol – An officially prescribed symbol (a magenta trefoil) on a yellow background that must be displayed where certain quantities of radioactive materials are present or where certain doses of radiation could be received.

Radioactive Materials – Any material that spontaneously emits ionizing radiation at levels significantly above natural background levels; the level of significance and the method of determination are established by EH&S Department in compliance with governmental regulations.

Radioactive Waste – A solid, liquid, or gaseous material from experiment/research operations that is radioactive and for which there is no further use.

Radioactivity – The spontaneous emission of radiation, generally alpha particles, beta particles, or gamma rays from the nucleus of an unstable isotope.

Radioisotope – An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation.

Registered Worker – An individual registered with the EH&S Department and approved for work involving the use of radioactive materials or radiation generating devices under the supervision of an Authorized User.

Rem – The special unit for dose equivalent. The dose equivalent in rem is equal to the absorbed dose in rads, multiplied by the quality factor.

***Removable Surface Radioactivity (Contamination)* –** Radioactive deposits on a surface that are removable by wiping the surface with a standard absorbent material and procedure.

***Reportable Spill* –** Any contamination of a person or unauthorized area or a spill of more than 1 millicurie of material in an authorized area. If a spill involves less than 1 millicurie and is confined to a controlled working area and can be cleaned up to nondetectable levels, it need not be reported.

***Roentgen (R)* –** A unit of exposure to ionizing radiation. It is that amount of gamma or x-rays required to produce ions carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, German scientist who discovered x-rays in 1895.

***Restricted Area* –** An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation or radioactive materials. Restricted area does not include areas used as residential quarters, offices, etc.

***Scintillation Detector* –** A radiation detection instrument comprised of a phosphor, photomultiplier tube(s), and associated electronic circuits for counting light emissions produced in the phosphor by ionizing radiation.

***Sealed Source* –** Radioactive material that is permanently bonded or fixed in a capsule or matrix designed to prevent release and dispersal under the most severe conditions which are likely to be encountered in normal use and handling.

***Secondary Radiation* –** Radiation originating as the result of absorption of other radiation in matter. It may be either electromagnetic (e.g. Bremstrahlung from ^{32}P betas passing through lead) or particulate in nature.

***Shallow Dose Equivalent* –** Applies to the external exposure of the skin or an extremity. This is the dose equivalent at a tissue depth 0.007 cm averaged over an area of 1 square centimeter.

***Shielding* –** Any material or obstruction that absorbs radiation and thus tends to protect personnel or materials from the effects of ionizing radiation.

***Survey Meter* –** Any portable radiation detection instrument especially adapted for inspecting an area to establish the existence and amount of radioactive material or contamination present.

***TLD (ThermoLuminescent Dosimeter)* –** A crystalline material which emits light when heated after radiation exposure; used in dosimetry.

***Whole Body* –** Refers to the head, trunk (including gonads), arms above the elbow, and legs above the knee.

Wipe Sample – Wiping of 100 square centimeters of a surface with a filter paper or a cotton swab for the purpose of determining if removable contamination is present. The wipe is then analyzed with a radiation detection instrument, such as a survey meter or a LSC.

X-rays – Penetrating electromagnetic radiation (photon) having a wavelength that is much shorter than that of visible light. They can be produced by excitation of the electrons around certain nuclei (characteristic x-rays) or by the interaction of high speed electrons with the electric fields around nuclei.

Appendices

A. Radiation Forms
B. Radiation Safety Training Outline
C. Electron Microscope System General Safety Protocol
D. Cabinet X-ray General Safety Protocol

Appendix A

Radiation Forms

1. Application for Authorization to Obtain and Use Radioactive Materials
2. Radiation Worker Registration Form
3. Radiation Purchase Request Form
4. Radiation Survey Form
5. Daily Use Inventory Log
6. Monthly Inventory Log
7. Iodination Log
8. Radioactive Waste Log
9. Radioactive Waste Pick-Up Form
10. Sewer Disposal Log
11. Notification of Minor Using Radioactive Materials or Radiation Generating Devices
12. Declaration of Pregnancy Form

The University of North Carolina at Greensboro

Application for Authorization to Obtain and Use Radioactive Materials

1. Applicant's Name: _____ Application Date: _____

2. Department: _____Office Location: _____

3. Office Phone: _____ Lab Phone: _____

4. Lab Location and Room Numbers: _____

5. Project(s) Title: _____

6. Radiological Data:

Radionuclides Requested and Maximum Quantities:

Radionuclide	Chemical Form	Activity (mCi)
1.		
2.		
3.		
4.		

7. Description: Provide a brief description of the experiment(s) and outline purpose or objectives.

8. Use and Storage Areas: Specify where radioactive materials will be used and stored. Describe security measures and protective equipment available (bench shields, lead shield, hood use, etc.)

9. Handling Procedures: Describe Procedures to be used to minimize personnel exposure and lab contamination.

10. Radiation Surveys: Describe instruments available to be used for monitoring lab areas, equipment, and personnel during experiments. Describe methods and frequency of monitoring for contamination of these areas.

11. Training and Experience of Applicant: Describe training and experience relating to use of radioactive materials in research, specifying radionuclides and quantities handled. Describe radiation safety training, including location and dates of training. Specify location and dates of work experience. Attach training certificates if available.

The University of North Carolina at Greensboro

Radiation Worker Registration Form

(Complete and submit for EH&S Department approval prior to radiation use)

Last Name:	**First Name:**	**MI:**
UNCG ID#:	**Status:** ☐ Faculty ☐ Staff ☐ Student	
Gender: ☐ Male ☐ Female	**Date of Birth:** (MM/DD/YYYY):	
Department:	**Authorization Holder:**	
Lab Building/Rooms:		
Education: ☐ H.S. ☐ Associate Degree ☐ Bachelor's Degree ☐ Master's Degree ☐Doctorate ☐Other (Specify)_____		
Training & Experience (Describe relevant radiation training and work experience):		
My Work Will Involve (Check all that apply): ☐ Radioactive Materials (unsealed) ☐ Analytical X-ray ☐ Sealed Sources of Radioactive Materials ☐ Cabinet X-ray ☐ DEXA Bone Densitometer ☐ Other (Specify):		

Nuclide or Machine	Hours per week	mCi per experiment	Operations/Procedures

Dominant hand used to handle radioactivity: ☐ Left ☐ Right ☐ N/A
Ring Size: ☐Small(~size 5) ☐Medium(~size 8) ☐Large(~size 11) ☐X-Large(~size 14)

Concurrent Employment: Do you currently work at another company or institution other than UNCG that involves exposure to radiation or radioactive material? : □ **Yes** □ **No**

(Note: For purposes of occupational radiation exposure monitoring, you are required to notify EH&S if you are now or later become a radiation worker for another employer.)

Previous Employment: Have you ever been monitored for occupational radiation exposure at any other company or institution other than UNCG? □ **Yes** □ **No**

Previous Employer (if "Yes" above, provide mailing address for most recent employer):

Company/Institution: _____

Department & Supervisor: _____

Street Address: _____

City, State, Zip: _____

Dates of Employment: From: _____ To: _____

I certify that the above information is accurate and complete to the best of my knowledge. I also authorize the UNCG EH&S Department to obtain occupational dose history records from my previous employer(s), if necessary, in accordance with the North Carolina Regulations for Protection Against Radiation.

_____ _____

Signature of Registrant **Date**

_____ _____

Signature of Authorization Holder **Date**

For EH&S Use Only

Initial EH&S Training Completed (Date):		
Account #:	Series Code:	Participant #:

Dosimeters Assigned (type & location)	Frequency	Effective Date

Comments & Approval _____

_____

_____

_____ _____

RSO Approval Date

University of North Carolina at Greensboro

Request for Purchase of Radioactive Materials

1. All Radioactive Materials purchase requests must be cleared by the EH&S Department.
2. Purchase requests must be submitted at least three working days in advance.
3. Forward all purchase request and this form to the EH&S Dept. (Fax 334-4206)

Authorization Holder: _____
Phone Number: _____
Email: _____

Vendor Name: _____
Vendor Contact Info: _____
_____
_____

Requested Delivery Date: _____
Building, room _____

Units (#of vials): _____
Catalog/Item #: _____
Compound Name: _____
Isotope: _____
Activity Per Unit (mCi): _____

Nuclide Possession Limit (mCi): _____
Current Nuclide Inventory (mCi): _____
Prospective Inventory with Purchase (mCi): _____

I hereby certify I am allowed to possess this material and that this purchase will not exceed my radioactive material possession limit.

Authorized User Signature: _____ Date:_____

To be completed by RSO

This purchase has been reviewed and verified by the Radiation Safety Officer.

Approved: _____ Disapproved: _____

Radiation Safety Officer Signature: _____ Date_____

Radiation Survey Form

Authorized User: _____

Surveyor: _____ **Nuclide(s) Used:** _____ **Date** _____

Survey Meter: _____ **Serial#** _____ **Calibration Due:** _____
(Make & Model)

An external radiation survey (Geiger meter) must be performed following use of high energy beta emitter (P-32). All authorized areas of use must be surveyed. Write "No Use" for any rooms not used.

Record wipe results (net DPM) below or attach printout.

Wipe#	DPM	Wipe#	DPM	Wipe#	DPM	Wipe#	DPM

All exposure rates are $\leq$ background levels (0.05 mR/hr) unless noted on map below.

University of North Carolina at Greensboro

Monthly Inventory Log

Authorized User:_____

NOTE: A monthly inventory summary must be recorded for each vial of Radioactive Material.

Date/ Month of record *(Ex. 2-1-13 / January)*	Vial#	Nuclide	Chemical Form	All Quantities in millicuries (mCi).				
				Beginning Balance	Transfer to other User (Specify)	Decay	Waste	Ending Balance

University of North Carolina at Greensboro

Radioactive Materials Daily Use Log

Authorized User:_____ Location:_____Date Rec'd_____

Vial#:_____ Radionuclide:_____ Quantity (mCi):_____Chemical Form:_____

NOTE: A copy of this form must be maintained for each stock vial received. Retain for three years after disposal date.

USE RECORD										
Transfers from shipping vial/stock solutions			**Decay**	**Transfer to another Authorized User (Specify User)**	**Quantity transferred to waste**					**Notes/ Remarks**
Date	**Removed (mCi)**	**Remaining (mCi)**			**Liquid Waste**	**Dry Waste**	**Liquid Scintillation Vials**	**Animal Carcasses**	**Sewer (if authorized)**	

The University of North Carolina at Greensboro

Radioactive Waste Log

Authorized User: _____ **Building/Room:** _____

Type: : ☐ Dry/Solid ☐ Liquid ☐ Scintillation Vial

Half Life: ☐ Long-lived (≥180 days) ☐ Short-lived (<180 days)

Date	Nuclide	Activity (mCi)	Description: Chemical Compound(s), Physical Characteristics (paper, plastic, etc.)

THE UNIVERSITY OF NORTH CAROLINA GREENSBORO	**RADIOACTIVE WASTE REMOVAL FORM**	Page___ of ___ Date:
Authorized User (please print legibly):	Building/Room:	Department:
	Email:	Telephone:

WASTE CONTENTS

Type (check one): ☐ **Solid** ☐ **Liquid** ☐ **Scintillation Vials** ☐ **Carcass/Tissue**

Totals by nuclide:		**Chemical Compound(s)** (Include % of each compound, enter brand name of scintillation fluid)	**Physical Form** (liquid, paper, plastic, etc.)
Nuclide	**Activity (mCi)**		

I hereby declare that the contents listed on this page are fully and accurately described by name, composition and quality, and that I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me.

Print Name _____ **Signature** _____ **Date:**_____
(Authorized User or Registered Worker)

Please mail of fax a copy of this form to the EH&S Department (fax 334-4206) and then attach form to container for pick-up by EH&S.

Received by EH&S:	**Date:**

SEWER DISPOSAL LOG

Authorization Holder:_____ Building/Room:_____

Sink Location:_____

Daily Sewer Disposal Limits (µCi)

^{3}H	1000	^{45}Ca	10
^{14}C	100	^{51}Cr	1000
^{32}P	10	^{55}Fe	100
^{33}P	50	^{125}I	1
^{35}S	100	^{131}I	1

***** EXPRESS AMOUNT ONLY IN µCi*****

Date: **MM/DD/YY**	**User Initials**	**Nuclide**	**Activity (µCi)**	**Comments**

****PLEASE WRITE LEGIBLY****

IODINATION LOG

Location:____________________ Authorization Holder_________________________

Name	Date	Authorization Holder	Radioisotope	Activity

The University of North Carolina at Greensboro

Notification of Minor Using Radiation

Name:	Date:
University ID#:	Birth Date:
University Telephone:	E-mail Address:
University Affiliation: ☐ Student ☐ Staff	Laboratory Location:

With this notice I inform you that I am between the ages 16 and 18 and a member of UNCG Community who intends to work with radioactive material or a radiation generating device. I will be working with the following radiation sources:

Radioactive Material (nuclide)	Typical Activity Used (mCi)	Chemical Form
X-ray Devices:		
Other Device:		

Please check the following as appropriate:

- □ I have questions related to the radiation protection and would like a health physicist from the EH&S Department to contact me at _____.
- □ I have questions related to the radiation protection of the embryo/fetus and will contact the Department of Environmental Health and Safety at (336) 334-4357.
- □ I do not have questions related to the radiation protection at this time. I understand that I may contact the Department of Environmental Health and Safety if I have any questions in the future.

_____ _____
Signature of minor Date

_____ _____ _____
Authorization Holder Signature Printed name Date

The University of North Carolina at Greensboro

Declaration of Pregnancy

I, _____, UNCG ID#_____, hereby certify and declare that I am pregnant or planning to become pregnant. I wish to participate in the fetal dose monitoring program offered by The University of North Carolina at Greensboro.

I have participated in a conference of fetal dose control policies and related safety information. A monthly radiation monitoring service has been established for me. I have received a copy of the fetal dose policy adopted by The University of North Carolina at Greensboro.

The following information is provided in support of this declaration:

Date of Declaration: _____

Date of Conference: _____

Estimated Pregnancy Due Date: _____

Estimated Conception Date: _____

_____ _____

Signature of Declared Radiation Employee Date

_____ _____

Signature of RSO Date

Appendix B

Radiation Safety Training Outline

The University of North Carolina at Greensboro

Radiation Safety Training Outline

A. Reasons for Training
    1. Scientific community
    2. Federal regulatory agencies
    3. State regulatory agencies
    4. Institution responsibilities:
        a. Radiation Safety Committee
        b. Radiation Safety Officer
        c. Authorized User
        d. Radiation Worker

B. Radiation Physics
    1. What is Radiation?
    2. Atomic structure
    3. Difference between ionizing and non-ionizing radiation
    4. Types of radioactive transformations (alpha, beta, gamma) and their characteristics

C. Radiation Units
    1. Activity
    2. Half-life
    3. Exposure
    4. Absorbed Dose
    5. Dose Equivalent

D. Biological Effects and Radiation Risk:
    1. Types of radiation effects (acute and delayed)
    2. Difference between stochastic and non-stochastic effects
    3. Radiation dose versus effect

E. Radiation Protection and General Safety
    1. Difference between contamination and exposure
    2. What is ALARA?
    3. Protection from exposure: time, distance, shielding
    4. Protection from internal contamination
        a. Containment
        b. Protective clothing/equipment
        c. Bioassay program
    5. Regulatory exposure limits:
        a. Occupational limits (adult, minor, declared pregnant woman)
        b. Members of the general public

6. Personnel monitoring:
    a. When is it necessary to monitor exposures?
    b. Monitoring for external sources
        i. Proper badge use
        ii. Proper badge storage
    c. Monitoring for internal sources (bioassay)
7. Surveys
    a. Radiation surveys
    b. Contamination surveys:
        i. Liquid Scintillation counting
        ii. Counting efficiencies (20% for H-3 & 50% for all beta-emitters.)
        iii. Gamma counting (if applicable)
    c. Action levels
    d. Survey documentation

F. Incident Response
1. Equipment (spill kit, protective equipment)
2. Assessment
3. Containment
4. Cleanup and decontamination
5. Personnel decontamination
6. Notifications

G. Records
1. North Carolina regulations, license and application
2. Radiation Safety Manual
3. Surveys
4. Inventory Records
5. Waste disposal records

Appendix C

Electron Microscope General Safety Protocol

The University of North Carolina at Greensboro

Electron Microscope General Safety Protocol

Machine Identification

Manufacturer:_____Model:_____

Location:_____ Principal Investigator:_____

General Safety Regulations:

1. Only personnel trained and approved by the responsible Principal Investigator may operate an electron microscope.
2. An operational fail-safe light is visible to the operator indicating when x-rays are being produced.
3. Use interlocks, barriers or administrative controls to ensure no one can gain access to the primary beam or high scatter radiation areas.
4. Use a calibrated thin-window GM survey meter to verify shielding effectiveness and monitor radiation levels.
5. Secure electron microscopes against unauthorized use by using a unit key control or the room lock. Stop the primary beam by secured shielding that cannot be readily displaced.
6. Secure unused ports to prevent accidental exposures.
7. Maintain an operating log that includes the date, operator, beam voltage, and current time on and off (or total exposure time).
8. Do not modify the built-in shielding and viewing ports. If modifications must be made, contact the EH&S Department for a safety survey of the unit.
9. Notify the EH&S Department immediately in the event of any suspected abnormal personnel radiation exposure.
10. Changes in the location or disposition of electron microscopes must have the approval of the EH&S Department. Notify the EH&S Department prior to the acquisition, disposal, or transfer of any electron microscope.
11. Contact the EH&S Department for information regarding radiation safety or radiation survey instrumentation.

Appendix D

Cabinet X-ray General Safety Protocol

The University of North Carolina at Greensboro

Cabinet X-ray General Safety Protocol

Machine Identification

Manufacturer:_____Model:_____

Location:_____Principal Investigator:_____

General Safety Requirements:

1. Only individuals identified on the Authorization may operate the machine. All authorized users must receive instruction in and demonstrate an understanding of the operation of the machine before starting unsupervised work.

2. An operational fail-safe light is visible to the operator indicating when x-rays are being produced.

3. Use interlocks, barriers or administrative controls to ensure no one can gain access to the primary beam or high scatter radiation areas.

4. Use a calibrated thin-window GM survey meter to verify shielding effectiveness and monitor radiation levels.

5. Whole body and finger ring dosimetry is required for all personnel working with cabinet units.

6. Do not use the safety interlock to turn the machine off; use the main switch.

7. Do not override the safety interlock, except for special procedures approved by EH&S.

8. Make sure the machine is OFF before changing samples or the primary tube safety shutter is closed and verify there is not active beam present; always check the current and voltage meters and /or use a survey meter to detect x-rays.

9. Do not modify the built-in shielding. If modifications must be made, contact the EH&S Department for approval to restart instrument.

10. Secure unused ports, if any, to prevent accidental exposures.

11. Secure cabinet units through a unit key control or room lock.

12. Maintain an operating log that includes date, operator, beam voltage and current, and time on and off (or total exposure time) for each unit use.

13. Notify the EH&S Department immediately if there is a concern for any abnormal personnel radiation exposure.

14. Obtain approval for any location changes, purchase or removal of diffraction/fluorescence units from the EH&S Department. Notify the EH&S Department prior to the acquisition, disposal, or transfer of any diffraction/fluorescence unit.

15. Contact the EH&S Department for information regarding radiation safety or radiation survey instrumentation. .