

## **Radiation Safety Handbook**

For

Authorized Users of Radioactive Materials

Issued by the  
General Radiation Safety Committee  
and EH&S Radiation Safety Program

Effective Date: January 2012

## FOREWORD

The North Carolina Radiation Protection Section has licensed Wake Forest University Health Sciences and Wake Forest University to use radioactive materials. The purpose of this HANDBOOK is to state the policies and procedures essential in conducting an effective radiation safety program. It is written for investigators using radioactive materials in their research.

All users of radioactive materials for non-human research must be familiar with the requirements given in this HANDBOOK. Failure to comply is a violation of conditions as contained in the institution's radioactive materials licenses and may result in loss of privileges to work with radioactive materials or other disciplinary action. As policies or procedures are revised, replacement pages will be provided as necessary. It is the responsibility of the Principal Investigator to maintain an updated copy of the HANDBOOK.

This HANDBOOK must be kept in a location available to all employees, EH&S Radiation Safety personnel and state inspectors from the North Carolina Radiation Protection Section. Additional copies are available from the Department of Environmental Health and Safety or on their website.

This HANDBOOK has been approved by the General Radiation Safety Committee.

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David C. Howell

Radiation Safety Officer

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Date

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## Section 1

### **ORGANIZATION AND RESPONSIBILITIES**

The purpose of the radiation safety program is to ensure that work with radioactive materials is conducted in such a manner as to protect and minimize risks to health, safety and property. Fulfillment of this purpose should be consistent with the educational and research goals of Wake Forest University Health Sciences (WFUHS) and Wake Forest University (WFU).

The purpose of the RADIATION SAFETY HANDBOOK FOR AUTHORIZED USERS OF RADIOACTIVE MATERIALS is to set forth the policies, organization, operating procedures and standards of conduct within the medical center's radiation safety program. Furthermore, it serves as a guide for individuals who have the authority to use radioactive materials in complying with University policy, conditions stipulated in the broad scope medical and academic radioactive materials licenses, and applicable local, state and federal regulations. This HANDBOOK only addresses the use of radioactive materials for non-human research.

Each Principal Investigator of Radioactive Materials will receive a copy of the RADIATION SAFETY HANDBOOK. The HANDBOOK shall be kept in the main laboratory where radioactive materials are used, along with all other radiation safety program records. The HANDBOOK is also available online at the Environmental Health & Safety website.

All persons using radioactive materials must be familiar with and comply with all provisions of this HANDBOOK.

#### **GENERAL RADIATION SAFETY COMMITTEE**

The General Radiation Safety Committee (GRSC), in accordance with 15A NCAC 11.0324, advises the Dean of the School of Medicine on all matters related to radiation safety and establishes such policies and procedures as it may deem appropriate to ensure an adequate radiation safety program.

Appointed by the Dean, Committee membership consists of a Chair, a representative of Administration, faculty members and a Radiation Safety Officer (RSO) experienced in the use of radionuclides and in protection against ionizing radiation. Members are appointed in July for three-year terms. The list of current Committee members is available online.

The Chair directs activities of the Committee, which meets at least quarterly. The Chair, the Administration representative and the RSO must be present at all meetings.

The GRSC has the ultimate responsibility for the use of radioactive material at WFUHS and WFU. It shall set policy and establish rules to be carried out by the RSO. It shall receive and review all pertinent reports and records of Environmental Health and Safety (EH&S) and shall keep and maintain a record of all its transactions and reports. The GRSC shall consider the liabilities of the WFUHS in all hazardous activities involving radionuclides.

## **RADIATION SAFETY OFFICER**

According to Department of Energy regulations (10 CFR 35.24): A licensee shall provide the Radiation Safety Officer sufficient authority, organizational freedom, time, resources, and management prerogative, to identify radiation safety problems; initiate, recommend, or provide corrective actions; and verify implementation of corrective actions. The RSO is responsible for the daily operations of the radiation safety program. The RSO is a member of the GRSC and refers matters to the Committee that require its review and approval.

The RSO has the authority to immediately terminate any unsafe practice or work activity without prior coordination with the GRSC or Administration. This authority includes unhampered access to all research projects utilizing radioactive materials or radiation. The RSO also has the authority to suspend or cease operations that are not in compliance with radiation safety regulations or license commitments.

## **ENVIRONMENTAL HEALTH AND SAFETY**

Radiation safety services are provided by EH&S for WFUHS and WFU. These services include (but are not limited to) oversight and administration of the personnel monitoring program, laboratory audits, package receipts and delivery, radioactive waste management and general radiation safety training.

Questions regarding the radiation safety program should be directed to the Radiation Safety Officer or the EH&S Radiation Safety Inspector assigned to the laboratory at 716-1276, Monday through Friday, 8 AM to 5 PM. After normal working hours, Radiation Safety may be reached via Security Personnel at 716-3305.

## **PRINCIPAL INVESTIGATORS OF RADIOACTIVE MATERIALS**

The Principal Investigator (PI) is a faculty member at WFUHS or WFU, who has submitted an application to EH&S Radiation Safety and has been approved by the GRSC to use radioactive materials. The PI is personally responsible for compliance with radiation safety policies and government regulations as they pertain to the authorized use of radioactive materials. Specific responsibilities include (but are not limited to):

- 1) Maintaining current and accurate records of the receipt, possession, acquisition, transfer, use, and disposal of radioactive materials (these records must be maintained for at least three years.). Inventory records are only required for radioisotopes which have a half-life greater than three days.
- 2) Submitting the yellow inventory card (if received) to EH&S Radiation Safety by the 16<sup>th</sup> day of each month or by electronic means.
- 3) Responding to any written *Notice of Violation* issued by EH&S Radiation Safety within 24 hours or 10 days, whichever is required as determined by the Radiation Safety Inspector.
- 4) Assuring that all radioactive materials are transported in such a manner to prevent contamination in the case of an incident. This can be accomplished by using closed unbreakable containers or secondary containment. In addition, use shielded transport containers if moving materials other than H-3 or C-14.
- 5) Using appropriate shielding in all areas where radioactive materials, including waste, are stored (Lucite or Plexiglas for beta emitters or lead for gamma emitters).
- 6) Pre-packaging sharp and/or breakable solid waste items in approved puncture-resistant containers before addition to any solid waste container.

- 7) Requesting additional radionuclides or changes in possession limits in writing to the RSO.
- 8) Receiving approval from the RSO prior to transferring radioactive materials to other Principal Investigators.
- 9) Consult with RSO prior to shipping radioactive materials anywhere off campus to determine compliance with Department of Transportation regulations.
- 10) Disposing of all radioactive waste through EH&S Radiation Safety. **There is no drain disposal (“hot sink”) in individual labs.**
- 11) Reporting promptly to the RSO (716-1276) any condition that may lead to unnecessary exposure to radiation or a violation of the rules outlined in this HANDBOOK.
- 12) Require that any personnel who will handle radioactive materials first attend monthly Radiation Safety training conducted by EH&S Radiation Safety.
- 13) Maintaining all documentation regarding the User’s radiation safety program and making these records available for review by EH&S Radiation Safety.
- 14) Notifying the RSO of intent to leave WFUHS/WFU at least 60 days in advance. The PI is responsible for disposing of radioactive materials inventory through EH&S Radiation Safety and for performing a final survey (smear and GM) to demonstrate all work areas are free of contamination. Results of this survey must be submitted to the RSO.
- 15) Notifying the RSO prior to any changes in locations where radioactive materials are stored or used. Do not use or store radioactive materials in these new locations until you receive approval from the RSO.
- 16) In the event of a spill or whenever lab surveys show the presence of removable contamination, continuing decontamination efforts until there is no removable contamination.
- 17) Performing weekly surveys of all use and storage areas each week that radioactive material is used in the laboratory. (Additional surveys may be performed.)
- 18) Documenting all survey results (including surveys following decontamination) and making these results available for review by EH&S Radiation Safety.
- 19) Notify the RSO immediately if you have lost or misplaced any radioactive material.
- 20) Instituting emergency action if EH&S Radiation Safety is not immediately available.
- 21) Send EH&S Radiation Safety a signed copy of the *Non-Employee Agreement* form (included in Section 7 of this HANDBOOK) for any employees who work with radioactive materials in the lab who are not employed by WFUHS/WFU.
- 22) Send EH&S Radiation Safety a signed copy of the *Temporary Lab Workers* form (included in Section 7 of this HANDBOOK) for any employees who work with radioactive materials in the lab but will only be in the lab for less than four months.

## AUTHORIZED USERS

An Authorized User is any person who is approved by EH&S Radiation Safety to work with radioactive materials. This person has a responsibility to:

- 1) Attend a monthly Radiation Safety training session offered by EH&S Radiation Safety prior to using radioactive materials.
- 2) Keep radiation exposure as low as reasonably achievable (ALARA.)
- 3) Minimize time spent near sources of radiation or radioactive materials.
- 4) Wear radiation dosimeters, if provided by EH&S Radiation Safety, when working with radioactive materials and turn them in for processing in a timely fashion.

- 5) Survey hands, shoes, body and clothing for contamination after using radioactive materials.
- 6) Use appropriate protective clothing (gloves, goggles, lab coats, sleeve protectors, etc.), automatic pipetting devices, fume hoods and shielding devices.
- 7) Never store food or drink in refrigerators or cold rooms used for radioactive materials.
- 8) Never eat, drink, smoke, apply cosmetics or remove contact lenses in areas where radioactive materials are used.
- 9) Practice good housekeeping in the laboratory.
- 10) Check work areas for contamination after performing procedures which use radioactive materials.
- 11) Decontaminate all work areas where contamination levels are greater than twice background. Re-survey the area after decontamination and document results.
- 12) Label, segregate and secure sources of radioactive materials, including waste.
- 13) Transport all radioactive materials in such a way to prevent contamination in the case of an accident. This can be accomplished by using closed unbreakable containers or secondary containment. In addition, use shielded transport containers if moving materials other than H-3 or C-14.
- 14) In the case of known or likely contamination to a person, both the person and clothing should be monitored. Clothing with contamination greater than twice background must remain in the laboratory for decay. (The contaminated clothing may also be packaged and brought to the EH&S Waste Holding Area for decay.) Decontaminate the skin immediately by rinsing with lukewarm (not hot, not cold) water. Notify EH&S Radiation Safety (716-1276).
- 15) Report promptly to the laboratory supervisor or the RSO (716-1276) any condition that may lead to unnecessary exposure to radiation or a violation of the rules outlined in this HANDBOOK.
- 16) Notify the RSO immediately if you have lost or misplaced any radioactive material.
- 17) Report any spill or accident involving millicurie quantities of radioactive materials immediately to EH&S Radiation Safety (716-1276).

## Section 2

### LICENSING REQUIREMENTS AND REGULATIONS

Wake Forest University Health Sciences and North Carolina Baptist Hospital have a broad scope medical license for educational, research and clinical use of radioactive materials. Wake Forest University has a broad scope academic license for research using radioactive materials. These licenses have been issued by the North Carolina Department of Environment and Natural Resources, Radiation Protection Section, Radioactive Materials Branch. These licenses specify radionuclides, possession limits for each radionuclide, locations for use and internal authorization procedures. Copies of these licenses are available for review at EH&S Radiation Safety.

Authorization must be obtained from the GRSC before any person may possess or use radioactive materials at WFUHS and WFU. No radionuclides may be received, used or removed from these institutions without prior approval of the GRSC. The exception to this rule is the receipt, possession and use of radioimmunoassay (RIA) kits, which are subject to the provisions as contained in 15A NCAC 11.0314. RIA kits are used under General License Number 034-2085-0G and are comprised of:

1. iodine-125 in units not exceeding ten microcuries each;
2. iodine-131 in units not exceeding ten microcuries each;
3. carbon-14 in units not exceeding ten microcuries each;
4. hydrogen-3 (tritium) in units not exceeding 50 microcuries each;
5. iron-59 in units not exceeding 20 microcuries each;
6. cobalt-57 in units not exceeding ten microcuries each;
7. selenium-75 in units not exceeding ten microcuries each;
8. mock iodine-125 reference or calibration sources in units not exceeding 0.05 microcuries of iodine-129 and 0.005 microcurie of americium-241 each.

### AUTHORIZATION TO USE RADIOACTIVE MATERIALS

Authorization to Use Radioactive Materials is granted by the GRSC provided the Principal Investigator (PI) meets the minimum qualifications and requirements. Accordingly, each PI must apply for an Authorization to Use Radioactive Materials by requesting and submitting an *Application for Use of Radioactive Materials* to EH&S Radiation Safety. The completed application is circulated for review to members of the General Radiation Safety Committee. If necessary, on behalf of the GRSC, the RSO may request additional information from the applicant. The Committee may also reject an application if the applicant does not meet the approval criteria.

Any potential new PIs who have no previous experience handling radioisotopes must work under an active PI for a period of time until the supervising PI feels that the applicant PI has an understanding of the PI roles and responsibilities; this supervised work experience must be documented. The supervising PI will then send a letter to the RSO attesting to new PI's training.

#### ***Application for Use of Radioactive Materials***

A copy of the *Application for Use of Radioactive Materials* is included in Section 7 of this HANDBOOK, as well as on the EH&S Radiation Safety Website. The application has been designed to standardize the responses of applicants. It is preferred that all submitted application be typed or filled out online; see form or website for instructions.

### ***Applicant Qualifications and Requirements***

Principal Investigators must have training or practical experience in the principles of radiation safety, radiation detection and measurement and biological effects of ionizing radiation.

The possession limit of each radionuclide to be used must be identified in the application. All locations of use (including cold rooms and counting equipment rooms) and storage must be specified. A brief description of the experimental design for each radionuclide must also be included.

The Committee must be provided the following information to evaluate the application:

- Previous training and experience with radioactive materials;
- Description of experiments, including radionuclide, experimental design, approximate activity per experiment, estimated number of experiments per month and type of laboratory animal (if applicable);
- Location of fume hood used for iodinations (if applicable);
- Description of radiation safety equipment to be used, including protective clothing, fume hood, locations of absorbent paper, beta and/or gamma shielding (if applicable), remote handling equipment and secondary containment for liquids;
- Emergency procedures;
- Security of radioactive materials;
- Radiation detection equipment (such as survey meters and/or LSC);
- Location of records;
- Estimates of generated radioactive waste;
- Estimates of generated hazardous waste (if applicable); and
- List of employees.

The PI is responsible for the orientation and any refresher training of all persons working under their Authorization. Each employee must be familiar with the radiation safety program.

### ***Approval and Notification***

Once the majority of the Committee has approved the application, the RSO notifies the applicant in writing of the authorized radionuclides, possession limits and locations of usage and storage. A Radiation Safety Inspector will be assigned to the PI for auditing of laboratory activity..

### **TERMINATION OF AUTHORIZATION**

Principal Investigators must notify the RSO at least 60 days prior to terminating the Authorization to leave or retire from the school of medicine or university. The PI is responsible for disposing of any radioactive materials inventory through EH&S Radiation Safety and for performing a final smear survey to demonstrate that all work areas are free of contamination. Results of this final survey must be submitted to EH&S Radiation Safety.

The PI may use the form *Request for Amendment to Radioactive Materials Authorization* (included in Section 7 of this HANDBOOK or online) to notify the RSO. The form may be submitted to the RSO via facsimile (716-0588), campus mail or electronically.

### **Amendment Process**

Amendments to the Authorization must be requested in writing to the RSO and must include sufficient detail for the RSO to evaluate adequately the proposed change.

The form *Request for Amendment to Radioactive Materials Authorization* (included in Section 7 of this HANDBOOK) may be submitted to the RSO via facsimile (716-0588), campus mail or online.

### **General Requirements for Laboratories**

All laboratories using beta (other than H-3) and gamma emitters are required to have access to portable survey instruments capable of assessing ambient radiation levels and contamination levels. Instrument calibrations or operational checks are completed annually by EH&S Radiation Safety.

Requirements for shielding or remote handling devices depend upon the external radiation levels of the specific radionuclides and the amounts used by laboratory personnel.

Generally, a normal campus laboratory with impervious lab bench tops and floors, meeting standard chemical laboratory requirements for ventilation, emergency showers, fire extinguishers, etc. will be sufficient. Experiments involving volatile components, gases, or fumes require use of exhaust hoods. The face velocity of such hoods is measured annually by EH&S Radiation Safety.

## **USER SURVEYS**

### **Weekly Area Surveys**

Principal Investigators are responsible for ensuring that *weekly* surveys (direct measurement with survey meter and smears) are conducted any week that radioactive materials are used in the lab. However, surveys must be completed as soon as possible after being used for radioisotopes with half-lives three days or less. Although more frequent checks may be performed, only the weekly surveys must be documented and available for review by EH&S Radiation Safety. If no radioactivity is used during the week, no survey is required; however, it must be documented that no survey was performed because no radioactivity was used. The PI is not required to start keeping this documentation until radioactive material has been added to his/her inventory for the first time since being approved.

Note: Once a PI has a zero inventory balance (i.e., no isotopes or waste) then surveys will not need to be documented until the next receipt of radioisotopes (package or transfer). Once this receipt occurs then documentation of weekly surveys must resume the same week.

### **Method**

Weekly smear surveys are required for all isotopes used during the week, except for Cyclotron produced radioisotopes (F-18, O-15, C-11, etc.). In addition, weekly surveys with a portable meter are required for all isotopes, except H-3.

### **Action Levels**

Areas where survey results are greater than twice background must be decontaminated. After decontamination the area must be re-surveyed and the results must be documented. Spills must be reported to EH&S Radiation Safety (as described in Section 6 of this HANDBOOK).

### **Records**

All weekly surveys must be documented. Smear results can be recorded in either cpm or dpm (if the isotope's efficiency for the counter is known). Records must include the following information:

- Date of survey
- Location of survey (such as building and room number)
- Instrument used
- Background radiation levels
- Radiation/contamination levels
- Name of person performing survey
- Corrective action(s) if applicable
- Re-survey results.

Records must be maintained in the laboratory and be available for review by EH&S Radiation Safety as well as State Inspectors. These records must be maintained for at least three years.

## **RADIONUCLIDE USE IN ANIMALS**

Approval to use radionuclides in animals requires authorization from both the Institutional Animal Care and Use Committee (IACUC) and the GRSC.

The PI must first be approved by the GRSC as a Principal Investigator of Radioactive Materials. This approval allows the PI to possess and use specific radioactive materials in specific locations on campuses. For use of radioactive materials in animals, the PI must address animal care issues and make provisions for collection and storage of animal carcasses and associated waste.

For each IACUC protocol that includes radioactive materials, the PI must submit a protocol to the IACUC via the eIACUC which is online protocol submission web application. Within this protocol you are required to upload a 'Hazardous Material' form which outlines how you plan to use radioactive material in animals. This form will be reviewed and approved by a member of Radiation Safety to ensure that you are allowed to use the radioactive material listed in the protocol and that you are authorized for the locations listed.

Additional information regarding the use of animals in research is available in the *IACUC Handbook of Policies and the Animal Resources Program (ARP) Handbook* available in the Office of Research. Specific instructions and recommendations will depend on the protocol, radionuclide(s), level of activity, frequency of use, number of animals and size of animal(s). The Animal Resources Program Operations Manager should be notified prior to actual use of any radioactive materials in live animals housed in the central animal facility.

## **EH&S RADIATION SAFETY LABORATORY AUDIT PROGRAM**

EH&S Radiation Safety personnel (Radiation Safety Inspectors) audit all laboratories of active Principal Investigators on a quarterly basis. Furthermore, an inspection will not be conducted if the PI has had a zero inventory balance since the last inspection.

The audits include review of all radiation safety related records, measurement of ambient radiation levels using portable survey instruments and measurement of removable contamination levels by smear surveys. Results of the laboratory audit program are presented quarterly by the RSO to the GRSC. Escalated enforcement action may be implemented for violations identified in the laboratories and research areas; the RSO will confer with the Chair of the GRSC to determine appropriate action. Documentation of the action will be maintained in the PI's records in the EH&S Office.

The following items are subject to evaluation during these audits:

- Materials used since last inspection
- Rooms posted as required (including "Notice to Employees" and Emergency Procedures)
- Adequate personnel monitoring/proper use & storage of dosimeters (if applicable)
- Routine use of gloves, lab coats, shielding and other appropriate protective equipment
- Signs/labels on source and waste containers, equipment
- Radiation Safety Handbook available
- Absorbent paper on usage areas
- Inventory/disposal records current
- No eating, drinking or smoking in usage areas
- No food/drink in storage areas (refrigerators, etc.)
- Area survey records current
- Fume hood operational/calibrated
- Survey meter available and operational/calibrated
- Purchase of new equipment (survey meter, liquid scintillation counter, gas chromatograph)
- Proper storage and security of radioactive materials
- Materials used only in approved areas
- Bioassays completed (if applicable)
- Trained personnel handling isotopes
- No contamination detected

The PI will receive written notification of any items of noncompliance. During the audit or after analyzing the smear survey data, EH&S Radiation Safety will immediately notify the laboratory if levels of contamination are greater than twice background. The User must decontaminate the area, re-survey or re-wipe the area and document the results at that time. If the contamination levels are still greater than twice background, operations must cease until the area is decontaminated and re-surveyed.

### ***Enforcement of Radiation Safety Program***

EH&S Radiation Safety will conduct audits on a quarterly basis to ensure compliance with the radioactive materials licenses and the *North Carolina Regulations for Protection Against Radiation* (15A NCAC 11).

**Notice of Radiation Safety Violation**

The Radiation Safety inspector will provide a *Notice of Radiation Safety Violation* to the PI if an item(s) of non-compliance is (are) observed during the routine quarterly audit of the laboratory. The PI shall be required to submit a written response to the RSO that describes the corrective action as well as any actions to prevent recurrence. Failure to submit the response in a timely fashion may result in revocation of the authorization to purchase radioactive materials, temporary suspension of the Authorization to Use Radioactive Materials or termination of the Authorization. (The latter may lead to denial of institution approval of any grant applications.)

Violation Codes:

- A. The violation or observed hazardous condition(s) require(s) *immediate* attention. Please take corrective action and provide written response to EH&S Radiation Safety within the next 24 hours. Failure to act may result in temporary suspension of your Authorization to use Radioactive Materials.
- B. Please take corrective action and provide written response to EH&S Radiation Safety within 10 working days. Failure to act may result in revocation of your authorization to purchase radioactive materials until the response is received by EH&S Radiation Safety.
- C. Corrective action(s) was (were) implemented during the inspection.

**Posting of Notice of Radiation Safety Violation**

Principal Investigators are required to post within 24 hours any *Notice of Radiation Safety Violation* issued by EH&S Radiation Safety during an audit. The *Notice*, along with the response from the PI, should be posted in the laboratory and must remain posted for 5 working days or until corrective action is implemented, whichever is longer.

**Repeat Violations**

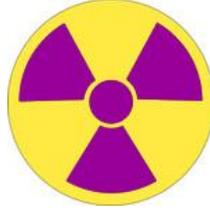
If a repeat violation is observed within a twelve month period, the Principal Investigator's department chair will receive a copy of the audit results. If a third violation of the same item occurs within a twelve month period of the previous violation, the Authorization will be suspended until the PI meets with the Chair of the GRSC and the RSO to justify continued use of radioactive materials. The Committee and the Senior Dean will be notified of the results of this meeting.

Committee action may include (but is not limited to):

- re-training of laboratory employees,
- placement of the User into a probationary status that will include increased frequency of EH&S Radiation Safety audits,
- limitation or suspension of the Authorization, or
- termination of the Authorization and removal of all radioactive materials by the RSO.

**WARNING SIGNS FOR RESTRICTED AREAS**

Radiation warning signs must include the following standard three-bladed radiation symbol (trefoil):



The signs must be magenta, purple or black on a yellow background.

Each area or room in which there is used or stored radioactive materials, must be posted with a conspicuous sign bearing the radiation symbol and the words "CAUTION RADIOACTIVE MATERIAL(S)." This posting is required on every room that a PI has designated in their application and amendments. This sign is only removed by EH&S Radiation Safety when a PI terminates his/her Authorization and it has been demonstrated that the room is free of contamination and nothing inside the room is posted as radioactive.

The exception to this rule is for rooms located in the Animal Resource Program. These rooms are temporarily posted by an Authorized User while conducting animal studies. When finished the user will conduct a radiation survey (in accordance with the User Surveys section on page 2-3) and if there is no contamination then the sign is removed from the room. This survey must be documented along with the PI's survey records.

### Section 3

## RADIATION EXPOSURE CONTROL (ALARA PROGRAM)

The acronym *ALARA* stands for *as low as reasonably achievable* – this principle of radiation protection implies that every effort should be made to reduce occupational exposure to a level as low as practicable.

### BASIC HANDLING REQUIREMENTS

Each person who uses radioactive materials is responsible for handling materials in such a way that personnel radiation exposures and levels of waste are as low as reasonably achievable. As described in the *Application to Use Radioactive Materials*, the Principal Investigator may prescribe specific precautions to employees.

### BASIC RADIATION SAFETY PRINCIPLES

Sources of radiation may be divided into two groups when considering physical principles for preventing or minimizing exposure. These groups include those sources that are external to the body and those sources that are internally deposited within the body.

#### ***Control of External Exposure***

External radiation exposure from a given radioactive source is controlled by the exposure time, distance from the source and shielding.

Decreasing the exposure time decreases the radiation dose proportionately. It is important to include “dry runs” with non-radioactive material for critical steps in preplanning all work that may involve substantial radiation exposure. Consideration of anticipated radiation dose is a fundamental aspect in preplanning work with radioactive materials.

Increasing the distance from the source is frequently the most effective and economical means to reduce radiation exposure from gamma rays and other highly penetrating radiations. The radiation exposure varies inversely with the square of the distance. For this reason, tongs or other long handled tools should always be used for manipulating radioactive preparations emitting significant levels of radiation. Radioactive sources should never be picked up with the fingertips; even low-level sources may be handled with short forceps that provide significant exposure reduction when compared with direct skin contact.

Shielding the source of radiation is necessary when the maximum distance and minimum time do not ensure a significantly low exposure to personnel. Shielding for gamma radiation is accomplished by interposing materials, preferably of high atomic number and high density, between the source and the area to be protected.

When high energy beta particles strike a material of high atomic number, the beta radiation produces penetrating x-rays called Bremsstrahlung. The intensity of Bremsstrahlung varies directly with the square of the beta energy and the atomic number of the shielding material. For this reason, low atomic number materials such as Lucite should be used for shielding beta radiation.

When working with energetic beta emitters, care must be taken to avoid exposing hands above open containers where the dose rate may be on the order of hundreds of rads per minute for commonly used quantities of beta emitters such as P-32. Where radioactive material emits both beta and gamma radiations, shielding considerations will be controlled by the gamma radiation.

Appropriate shielding must be provided so that the radiation exposure rate is less than 2 mR/hr in any controlled area.

### ***Control of Internal Exposure***

Time, distance and shielding are obviously not available for protection against radioactive materials internally incorporated within the body. Incorporation of radioactive material into the body is controlled by *preventing* the injection, inhalation, ingestion or absorption of such material. Accordingly, all significant quantities of unsealed radioactive materials must be used inside properly designed exhaust ventilated enclosures. Protective clothing, such as laboratory coats and gloves, should be worn when working with radioactive material. Contamination control must be practiced.

Another reason for preventing radioactive contamination is to assure reliable experimental results, avoiding contamination of radiation measuring instruments and cross-contamination of experiments.

### ***Laboratory Radiation Safety Rules***

1. All laboratory workers using radioactive materials must first receive radiation safety training by EH&S Radiation Safety.
2. Wear disposable gloves, lab coats and radiation monitoring devices (if provided) at all times when handling radioactive materials.
3. Use appropriate shielding when working with gamma or high-energy beta emitters.
4. Dispose of radioactive waste properly and regularly through EH&S Radiation Safety. Do not allow radioactive waste to accumulate within the lab.
5. Store radioactive materials in closed containers.
6. Transport all radioactive materials in such a way to prevent contamination in the case of an accident. This can be accomplished by using closed un-breakable containers or secondary containment. In addition, use shielded transport containers if moving materials other than H-3 or C-14.
7. Use radioactive material only on designated bench tops or designated work areas. Work surfaces should be covered with absorbent paper and spill trays should be used when working with significant liquid volumes of radioactive material.
8. Use an exhaust hood when working with volatile radioactive compounds (e.g., I-131, I-125 or H-3).
9. Never pipette radioactive solutions by mouth.
10. When starting a new procedure where radioactive materials will be used, perform a "practice run" without using the radioactive component to become familiar with the techniques employed.
11. Do not eat, drink, smoke, store food or apply cosmetics laboratories or any other area where radioactive materials are used or stored.

12. Perform and document weekly surveys of all areas where radioactive materials are used or stored. If no radioactive material is used during the week, no survey is required. However, you must document that no survey was performed because no radioactivity was used. Weekly smear surveys are required for all isotopes used during the week, except for Cyclotron produced radioisotopes (F-18, O-15, C-11, etc.). In addition, weekly surveys with a portable meter are required for all isotopes, except H-3.
13. Decontaminate all contaminated surfaces (that are not covered with absorbent paper) to the extent that all contamination in excess of twice background is removed. Remove all contaminated absorbent pads. Place all contaminated cleaning items in proper radioactive waste containers.
14. Wash hands thoroughly upon leaving the laboratory, especially before eating, drinking, smoking or applying cosmetics.
15. Use remote handling equipment (such as tongs or forceps) when handling source vials or large amounts of gamma- or high energy beta-emitters.
16. Radioactive materials must be properly secured (locked in a storage container or room) when personnel are not present. Additionally, unauthorized personnel should not be allowed in areas where radioactive materials are used or stored unless accompanied by properly trained personnel.
17. All doors providing access to areas where radioactive materials are used must be posted with "Caution - Radioactive Material" signs. Additionally, all contaminated equipment or equipment containing radioactive material must be properly labeled with "Caution - Radioactive Material" signs.

## REQUIREMENTS FOR LABELING RADIOACTIVE MATERIALS

All containers in which radioactive material is used or stored must be conspicuously labeled with a standard radiation warning label. The radiation symbol must be the standard three-bladed design and the label must be magenta, purple or black on a yellow background. Furthermore, the label must include the words "CAUTION - RADIOACTIVE MATERIAL(S)," the radionuclide, the amount of radioactivity and the date for which activity is estimated.

Secondary containers such as individual test tubes need not be labeled if they contain quantities less than those listed in the following table. However, a radioactive warning label should be affixed to items such as centrifuges that may become contaminated, particularly if the equipment is used by laboratory staff not working with radioactive materials. All radioactive waste storage containers must also be labeled.

### QUANTITIES OF RADIOACTIVITY REQUIRING WARNING LABELS

RADIONUCLIDE	MICROCURIES	RADIONUCLIDE	MICROCURIES
Hydrogen-3	1000	Cobalt-57	100
Carbon-11	1000	Iron-59	10
Carbon-14	100	Zinc-65	10
Fluorine-18	1000	Rubidium-86	100
Sodium-22	10	Technetium-99m	1000
Phosphorus-32	10	Indium-111	100
Phosphorus-33	100	Iodine-125	1
Sulfur-35	100	Iodine-131	1
Chlorine-36	10	Xenon-133	1000

Calcium-45	100	Cesium-137	10
Chromium-51	1000	Mercury-203	100

REGULATIONS REQUIRE LABELING OF EACH CONTAINER OF RADIOACTIVE MATERIALS EXCEEDING THE QUANTITIES SHOWN ABOVE. THE LABEL MUST BE DURABLE WITH A CLEARLY VISIBLE RADIATION WARNING SYMBOL AND THE WORDS "CAUTION - RADIOACTIVE MATERIAL(S)."

The label must provide sufficient information (radionuclide, quantity of radioactivity, date for which the activity is estimated) to permit individuals handling or using the containers, or working in the vicinity of the containers, to take precautions to avoid or minimize exposure.

## Section 4

### PROCUREMENT, RECEIPT, INVENTORY, TRANSFER AND DISPOSAL OF RADIOACTIVE MATERIALS

#### PROCUREMENT OF RADIOACTIVE MATERIALS

Principal Investigators (PI) must order all radioactive materials on the specific purchase requisition forms designated for this material. When the Purchasing Department receives an order, they contact EH&S Radiation Safety for approval prior to placing the order. This approval verifies that the PI is authorized to possess, use or store that radionuclide and quantity.

#### RECEIPT OF RADIOACTIVE MATERIALS

Any package containing radioactive material is delivered by carrier to Shipping and Receiving, **Monday through Friday from 8 AM to 5 PM**, unless pre-arranged with the Radiation Safety Officer (RSO) for other delivery times or locations. EH&S Radiation Safety signs for the packages in Shipping and Receiving and monitors them as required by the *North Carolina Regulations for Protection Against Radiation*. The packages are then delivered to the Principal Investigators, along with cards for shipping records, by EH&S Radiation Safety. RIA kits are exempt from monitoring for radiation and contamination and may be delivered directly to the end user.

The PI or designee must inspect the package and notify EH&S Radiation Safety *immediately* if any of the conditions are found:

1. The wrong radioactive material or incorrect amount has been delivered.
2. There is evidence of leakage of liquid on the outside of the shipment package, or
3. Upon opening the package, there is any evidence of leakage of radioactive material or any apparent break or compromise of the container, or
4. Upon opening the package, it is found that the actual source activity differs from that listed on the shipping manifest or packing list.
5. The PI or designee must immediately notify the RSO if any package containing radioactive material was not delivered by EH&S Radiation Safety staff.

#### ***Inventory and Records of Radioactive Material***

The *North Carolina Regulations for Protection Against Radiation* requires licensees to maintain accurate records of the receipt, use, transfer and disposal of all radioactive materials. These records must be maintained for at least three years or until termination of the Authorization, and must be available for review by EH&S Radiation Safety during quarterly audits as well as State Inspectors.

PIs are required to keep specific records of each shipment on the green card entitled *Investigator Shipment Record*. This card is provided by EH&S Radiation Safety with each package that is delivered to the laboratory. RIA kits and radioisotopes with a half-

life less than three days are not to be included in the Inventory Log. In addition, for inventory purposes radioactive decay is not utilized.

**All** radioactive waste must be disposed of through EH&S Radiation Safety. **Drain disposals are not allowed.** With each disposal, the User must present the appropriate Investigator Shipment Record card to EH&S Radiation Safety. A Disposal Number for each batch of waste (along with the amount of radioactivity, date of disposal and remaining activity) is recorded on the green card.

By the sixth day of each month, PIs receive a yellow *Inventory* card from EH&S Radiation Safety only if their inventory has changed since the sixth day of the previous month. The PI completes the card with the quantity of each radionuclide in possession.

The PI must return the yellow *Inventory* card to EH&S Radiation Safety by the 16<sup>th</sup> day of each month by campus mail or electronic. The inventory of each PI is compared to the records in the EH&S Radiation Safety Radioactive Inventory Log. Discrepancies are immediately investigated by EH&S Radiation Safety.

## TRANSFER OF RADIOACTIVE MATERIALS

Radioactive materials may be used or stored by PI in a variety of locations pending approval by the General Radiation Safety Committee. This necessitates the transfer of materials from one location to another. Furthermore, situations may require transfer of materials from one campus to another, one PI to another, or to another institution. In this case the PI **must** contact EH&S Radiation Safety at 716-1276 for further information or guidance.

### ***Transportation throughout the Campus***

The transportation of radioactive materials between areas of authorized use (between laboratories or from labs to the Waste Holding Area for disposal) must be performed in such a manner as to minimize the potential for accidental contamination of hallways, elevators, etc and personnel. To safely transport any radioactive materials:

- Use proper shielding when warranted (such as Lucite containers when transporting millicurie quantities of P-32 or lead “pigs” when transporting millicurie amounts of gamma emitters).
- If transporting source vials, use the shipping carton and packaging provided by manufacturer.
- If transporting bulk aqueous liquids, use unbreakable containers and surround the containers with a secondary containment system able to contain twice the volume of the inner containers. Make sure that all tops, lids, etc are securely closed prior to transport.
- Solid waste, carcasses or scintillation vials must be transported in securely sealed plastic bags.

Radioactive materials must *never* be left unattended during transportation from one location to another.

***Transportation between Campuses***

EH&S Radiation Safety **must** be notified by the PI prior to transporting any radioactive material between campuses (such as Bowman Gray to PTCRC/PTRP.) Proper containers and packaging must be used to meet Department of Transportation (DOT) requirements. Package surveys and wipe tests must be performed and shipping manifests completed by EH&S Radiation Safety.

***Transfer between Principal Investigators on the Same Campus***

Radioactive material may be transferred from one PI to another on the same campus. EH&S Radiation Safety **must** be notified in advance to assure that:

- The recipient PI is authorized to use the radionuclide and activity to be transferred.
- The activity is removed from the donor's inventory and added to the recipient's inventory.

***Transfer between Principal Investigators at Different Campuses***

Radioactive material may be transferred between PIs located on separate campuses (such as Bowman Gray to PTCRC/PTRP.) EH&S Radiation Safety **must** be notified in advance to assure that:

- The recipient is authorized to receive the radionuclide and activity to be transferred.
- The activity is removed from the donor's inventory and added to the recipient's inventory.
- Proper containers and packaging are used to meet DOT requirements.
- Package surveys and wipe tests are performed to meet DOT requirements.
- Shipping manifests are completed to meet DOT requirements.

***Transfer to Other Institutions***

Radioactive material may be transferred to another institution only if that institution possesses a radioactive materials license issued by the Nuclear Regulatory Commission or the regulatory agency of an Agreement State. To send radioactive material to another institution, EH&S Radiation Safety **must** be notified in advance. The RSO must contact the RSO at the other institution to obtain approval to send the material and to obtain a copy of the other institution's license. We must ensure that any packages offered for transport complies with DOT regulations and that appropriate package surveys and wipe tests are performed.

### ***Transfer from Other Institutions***

Before radioactive material may be transferred from another institution to a PI, the PI **must** contact EH&S Radiation Safety to obtain approval to receive that particular radionuclide and quantity. Additionally, the RSO at the other institution is required to contact our RSO for approval before the shipment is made. Also, a copy of our radioactive materials license must be on file at the other institution prior to any shipment of materials.

## **DISPOSAL OF RADIOACTIVE MATERIALS**

**All radioactive materials must be disposed of through EH&S Radiation Safety. Drain disposals are not allowed.** On the Bowman Gray Campus, waste collection times are Tuesdays and Fridays from 10 AM until 12 NOON. Radioactive waste must be brought to the Waste Holding Area located on the "E" Level of the Commons Building (adjoining Medical School Shipping and Receiving). Radioactive waste generated by users at PTCRC may be collected at PTCRC on alternate Wednesdays between 1:30 PM and 2:30 PM. Waste generated at the Friedberg campus may be collected at Friedberg on alternate Wednesdays from 10:00 AM and 11:00 AM. Waste collection calendars are available from EH&S. Collections at the Reynolda campus and the RJR Bowman Gray Technical Center are provided upon request.

Special collections (e.g., radioactive carcasses) may be arranged upon request calling EH&S Radiation Safety at 716-1276 and making an appointment.

## **WASTE SEGREGATION**

**Long-lived solids** with H-3, C-14, Co-57 or any isotope with a half-life of greater than 90 days must be sealed in 4-6 mil plastic bags. Long-lived solid waste must contain *no* liquids including scintillation fluids, carcasses, tissue, blood or blood products. Source vials of long-lived isotopes *if not empty and dry* should be segregated from the rest of the solid waste and presented separately at disposal time.

**Short-lived solids** with P-32, P-33, I-125, I-131, Cr-51, S-35 or any isotope with a half-life of less than 90 days must be sealed in 4-6 mil plastic bags. *All radioactive materials or radiation warning tape must be removed prior to disposal.* I-125, I-131, P-33 and Cr-51 solid waste may be combined. P-32 and S-35 solid waste should be packaged separately. Source vials, whether dry or containing small volumes of liquid, may be placed in bags with short-lived solid waste *provided all radioactive materials or radiation warning labels are removed or defaced.* All bags must be securely sealed.

**Aqueous liquids** must be collected in tightly sealed break-resistant plastic containers having volumes of 1 to 2 liters. (IV solution bottles are fine.) A limited number of small containers for this purpose are kept in the waste holding area and are made available to the laboratories on a “first-come, first-serve” basis. If a Principal Investigator is going to be routinely generating large volumes of aqueous liquids, it is recommended that he/she purchase 2 or 3 five-gallon plastic carboys for storing and transporting their aqueous radioactive liquids). In some cases, multiple isotopes may be combined in the same container with prior permission of EH&S Radiation Safety. *All radioactive materials or radiation warning tape must be removed from aqueous liquid containers prior to disposal with the exception of any carboys purchased by the Principal Investigator.*

**Bulk organic liquids** (other than scintillation fluids in vials) contaminated with radioactive material constitute a “mixed” waste and must be considered on a case-by-case basis with regards to disposal *before* being generated by the Principal Investigator. Historically, this type of waste material is prohibitively expensive to dispose of and researchers are strongly urged to avoid generating this type of material.

**Scintillation vials** containing radioactive scintillation media should be collected in 4-6 mil plastic bags in volumes *not to exceed 0.5 cubic feet per bag*. Scintillation vials containing H-3, C-14, and I-125 may be combined in the same bag. Scintillation vials containing S-35 or P-32 should be segregated and presented separately. *All radioactive materials or radiation warning tape must be removed prior to disposal. All bags must be securely sealed.*

Researchers are *strongly* encouraged to use aqueous-based “biosafe” scintillation fluids to reduce the levels of harmful vapors emitted by the older, organic cocktails in the laboratory environment.

**Carcasses** should be double-bagged in 4-6 mil plastic bags and, when possible, frozen prior to disposal through Radiation Safety. Tissue, blood and blood products, and associated bedding are considered as “carcass”. All bags must be securely sealed. *All radioactive materials or radiation warning tape must be removed prior to disposal.*

**Radioactive sharps** including needles, scalpel blades, etc. must be placed in approved sharps disposal units. These containers are available from WFUHS Environmental Services; additional information on sharps disposal units is available from EH&S.

All lead shipping containers must be segregated and presented separately from other waste. *All radioactive materials or radiation warning labels must be removed or defaced prior to disposal.*

## Section 5

### PERSONNEL DOSIMETRY

Individuals may receive radiation dose from sources external to the body and from internally deposited radionuclides. Accordingly, both external and internal hazards must be considered when evaluating the engineering and administrative controls of radiation exposure.

#### EXTERNAL RADIATION DOSIMETRY

##### *Types of Dosimeters*

Luxel® OSL dosimeters are currently used to monitor occupational whole body radiation exposure to betas, gammas, x-rays or neutrons. Thermoluminescent dosimeters (TLDs) may also be used to monitor whole body doses, but because of their small size, they are used to monitor radiation exposure to extremities. Electronic pocket dosimeters are also occasionally used to monitor acute radiation exposure.

##### *Issuing Dosimeters*

Regulations require monitoring of individuals who may receive, in one year, 10% of the occupational dose limits. You may contact the Radiation Safety Office to see if dosimetry would be necessary since normally researchers here do not exceed the aforementioned action level. An exception to this would be any Declared Pregnant Workers.

##### *Exchange of Dosimeters*

Each department or group of employees has a coordinator designated by EH&S Radiation Safety. The individual user is responsible for exchanging the dosimeter(s) with the coordinator within the first five working days of the month. Timely exchange of badges is *critical* for accurate dose assessment and up-to-date exposure records.

Whole body and ring dosimeters used for research purposes are exchanged quarterly. PET research personnel exchange their badges on a monthly basis. However, if contamination or a serious exposure is suspected, EH&S Radiation Safety should be notified immediately.

##### *Proper Use of Dosimeters*

A badge is to be worn only by the person to whom it is issued. Personal badges must not be loaned to other employees or used to monitor work areas. (Badges for monitoring work areas are available upon request from EH&S Radiation Safety.)

Dosimeters must be worn on the body at the location of highest potential exposure. For example, x-ray technologists working in Radiology who wear lead aprons should wear their film badges at the collar outside of the apron – the badge monitors exposure to the unprotected head and lens of the eyes. In research laboratories, badges should be worn on the torso.

Ring dosimeters must be worn if there is potential significant exposure to the hands. If only one ring is issued to the employee, the ring should be worn on the dominant hand with the

TLD turned toward the inside of the hand (palm). The dosimeter must be worn under gloves to protect it from contamination.

Badges must be worn when working with or around any sources of radiation or radioactive materials at WFUHS or WFU. If an employee is concurrently working with radiation or radioactive materials at another institution, the RSO should be notified; the other institution should provide the employee with a dosimeter to monitor radiation exposure incurred in that facility.

Do not wear badges while undergoing personal medical or dental x-rays. If an employee undergoes a diagnostic or therapeutic nuclear medicine procedure, the RSO must be notified. (Occupational dose limits are not applicable in these instances.)

Dosimeters must be exchanged and returned promptly to EH&S Radiation Safety for processing.

Dosimeters are heat sensitive and should not be stored or left in high temperature areas (e.g., inside of automobiles on sunny days).

### ***Obtaining Dosimeters***

Employees may request dosimeters from EH&S Radiation Safety by submitting a completed *Personnel Dosimeter and Radiation Exposure History Request* form (included in Section 7 of this HANDBOOK or online). This form must include the full name of the individual, Social Security number, date of birth, Principal Investigator and department; the employee must sign the form. EH&S Radiation Safety will review the request and determine if dosimetry is required, and if the employee has taken radiation safety training.

### ***Lost Badges***

If an individual loses a dosimeter, the employee must notify EH&S Radiation Safety in order for a spare badge to be issued for the remainder of the monitoring period. The individual must submit a *Lost Badge* form (included in Section 7 of this HANDBOOK or online) with comments regarding the radionuclides and quantities used by the employee prior to losing the badge. This information will be used by EH&S Radiation Safety to determine whether any special calculations must be performed to assess the individual's dose for that monitoring period.

### ***Obtaining Records of Exposure***

Upon written request to EH&S Radiation Safety, an individual may obtain a record of his/her radiation exposure and the results of any measurements, analyses or calculations of radioactive materials deposited within his/her body. The written request must include the name of the individual, Social Security number, date of birth, department where the individual worked and the dates of employment; the request must be signed.

Dosimeter results available from EH&S Radiation Safety include monthly (if applicable), quarterly (if applicable), current (year-to-date), yearly and lifetime doses.

## **INTERNAL RADIATION DOSIMETRY**

When individuals use quantities of radioactive materials that present potential for internal deposition, bioassays are required. Specific bioassay requirements have been established for personnel using radioactive iodine and tritium. EH&S Radiation Safety provides the monitoring services.

### ***Thyroid Bioassays***

Thyroid monitoring must be provided within 24 -72 hours for:

- Individuals working with more than 5 mCi of I-125 or I-131 in a single procedure, and
- Individuals working with more than 10 mCi I-125 or I-131 in multiple procedures over a period of one month.

EH&S Radiation Safety provides reminder notices when delivering packages of radioiodine to Principal Investigators with personnel who may meet these criteria. However, the individual user is responsible for contacting EH&S Radiation Safety to schedule thyroid monitoring.

### ***Tritium Bioassays***

Tritium urinalysis must be performed for individuals:

- Within one week following a single operation utilizing more than 100 mCi of H-3 in a non-contained form, other than metallic foil,
- Within 24 hours of a one-time use of 100 mCi of unencapsulated H-3, if internal deposition is suspected, or
- Monthly when quantities equal to or greater than 100 mCi of unencapsulated H-3 are handled regularly.

EH&S Radiation Safety will provide reminder notices when delivering packages of tritium to Principal Investigators with personnel who may meet these criteria. However, the individual user is responsible for contacting EH&S Radiation Safety to schedule urinalysis monitoring.

Tritium urinalysis must be performed within 24 hours following an accident that results in contamination (such as skin cut, abrasion or injection). If such an incident occurs, EH&S Radiation Safety must be notified immediately at 716-1276.

## OCCUPATIONAL EXPOSURE LIMITS

Occupational dose to individuals *must not exceed* the following annual limits:

	ADULTS	MINORS
Whole body, including head and trunk, active blood forming organs, and gonads	5,000 mrem	500 mrem
Lens of the eye	15,000 mrem	1,500 mrem
Each extremity (hand)	50,000 mrem	5,000 mrem
Skin	50,000 mrem	5,000 mrem

Regulations require monitoring of individuals who may receive, in one year, 10% of these limits. Whenever these limits have been reached or exceeded, the individual may be required to avoid future work with radiation or radioactive materials for a period of time.

## FETAL MONITORING

The dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, must not exceed 500 mrem. This includes both external exposure and the dose from any internally deposited radionuclides in the pregnant woman and the embryo/fetus. Furthermore, efforts must be made to avoid substantial variation above a uniform monthly occupational exposure rate to a declared pregnant woman.

If the dose to the embryo/fetus is found to have exceeded 450 mrem by the time the woman declares her pregnancy, the additional dose to the embryo/fetus must not exceed 50 mrem during the remainder of the pregnancy.

Employees may declare their pregnancy by submitting a completed *Declaration of Pregnancy* form (included in Section 7 of this HANDBOOK or online). The Radiation Safety Officer or designee will review the employee's job description, responsibilities and any available dosimetry information to determine if additional radiation monitoring or safety precautions are needed. The employee may withdraw her declaration of pregnancy for any reason.

### ***Determination of Embryo/Fetus Dose Prior to Declaration of Pregnancy***

The embryo/fetus dose from the estimated conception date to the pregnancy declaration date must be determined by EH&S Radiation Safety. For a woman working in a research lab who has been issued a monitoring device, the results of a TLD worn on the torso will be used for this estimate. If the woman has been monitored for internal exposures, the results will also be included the estimate.

### ***Embryo/Fetus Monitoring Device***

- After a pregnancy is declared and the RSO or designee has determined that additional radiation monitoring is required, the RSO or designee will issue to the worker a film badge to monitor the embryo/fetus dose.
- The embryo/fetus monitor must be worn on the waist of the pregnant worker.
- If the pregnant worker routinely wears a lead apron, the embryo/fetus monitor must be worn on the waist **under** the lead apron. The other badge must be worn at the collar outside of the lead apron.
- The embryo/fetus monitor must be exchanged monthly.
- Records of dose to an embryo/fetus will be maintained with the records of dose to the declared pregnant worker.

### **GENERAL PUBLIC DOSE**

The total effective dose equivalent to individual members of the public must not exceed 100 mrem in a year due to operations governed by the broad scope licenses. Furthermore, the external exposure to an individual in any unrestricted area must not exceed 2 mrem in any one hour.

These same limits apply to members of the public who have access to controlled areas. Accordingly, EH&S Radiation Safety deploys environmental monitors throughout the campus to estimate doses to individual members of the public.

### **ALARA LETTERS**

EH&S Radiation Safety regularly reviews dosimetry records not only for over-exposures but also for unusually high exposures for particular departments or work assignments. Individuals who receive 200 mrem or more for a one month time period are sent notices (called ALARA letters) from the RSO reminding them to keep exposures as low as reasonably achievable. Individuals who receive greater than 300 mrem in a one month time period must submit a written response to the RSO with a possible explanation for the high dose. Regardless, the General Radiation Safety Committee reviews the list of employees who receive ALARA letters and their responses (if applicable).

This information is used to determine whether additional administrative controls or engineering controls are necessary to reduce occupational exposures. It is also being incorporated into the annual review of the radiation protection program to evaluate its effectiveness.

### **DOSIMETRY RECORDS**

EH&S Radiation Safety maintains complete and accurate personnel dosimetry records for each employee issued a dosimeter. An individual may obtain a copy of his/her records by submitting a written request to EH&S Radiation Safety. The written request must include the name of the individual, Social Security number, date of birth, department where the individual worked and the dates of employment; the request must be signed. Results of any thyroid bioassays or tritium bioassays will be sent to each individual for his/her own personal records.

***Prior Occupational Dose***

Regulations require EH&S Radiation Safety to attempt to obtain records of lifetime cumulative dose for each employee issued a dosimeter. Individuals who have worked previously with radiation or radioactive materials and wore dosimeters must provide EH&S Radiation Safety with the names and addresses of these prior employers. The *Personnel Dosimeter and Radiation Exposure History Request* form (included in Section 7 of this HANDBOOK or online, and submitted to request a dosimeter) includes a location for the employee's signature; this signature authorizes the former employers to release the individual's dose records to EH&S Radiation Safety.

***Investigations of Overexposures***

The RSO must notify the North Carolina Radiation Protection Section in cases of known or suspected exposure above the occupational dose limits. Upon completion of an investigation of the overexposure, a report will be provided to the individual involved.

**DOSIMETERS FOR SUBCONTRACTORS, VISITORS AND GUESTS**

Authorized Users who are responsible for the presence of outside contractors, visitors or guests in any laboratory where radiation or radioactive materials are used **must** notify EH&S Radiation Safety. Considering the general public dose limit to individuals in restricted or controlled areas, the RSO will determine whether and what personnel dosimetry is necessary.

**Section 6****EMERGENCY PROCEDURES****GENERAL PROCEDURES**

The following general plans should be used whenever an incident has occurred involving radioactive materials.

***Minor Spills (involving a few microcuries)***

1. Cover the spill with absorbent paper.
2. Notify persons in the area that a spill has occurred. If necessary, evacuate personnel to a safe distance in order to limit the chance of further spread of contamination.
3. Wear disposable gloves. Use tongs if available. Carefully fold the absorbent paper or pad. Perform a survey of the immediate area and decontaminate the area as necessary. Insert all contaminated items (including gloves and the absorbent paper or pad) into a plastic bag for disposal in a radioactive waste container.
4. Report the incident to EH&S Radiation Safety at 716-1276. A radiation safety specialist may come to your laboratory to verify that the area has been decontaminated. The person responsible for the spill may be asked to submit a written report of the incident to the Radiation Safety Officer.

***Major Spills (involving a few millicuries)***

1. Notify all persons not involved in the spill to vacate the room.
2. Cover the spill with absorbent towels or pads, but do NOT attempt to clean up.
3. Leave the room and prevent further entry.
4. *Immediately* notify EH&S Radiation Safety at 716-1276 for assistance with decontamination.
5. Stay in the immediate area and retain all involved persons in a safe area outside the room. EH&S Radiation Safety personnel may monitor individuals for potential contamination. The person responsible for the spill may be asked to submit a written report of the incident to the Radiation Safety Officer.

***Emergencies after 5 PM, Weekends and Holidays***

1. Call the Operator at 716-9111.
2. Report that you have a radiation emergency.
3. Give the Operator your name, location and telephone number.
4. The operator will contact the appropriate individuals.

## **CONTAMINATION OF PERSONNEL**

### ***Serious Injury***

Medical treatment for serious injuries should never be delayed due to radioactive contamination.

1. Immediately provide emergency care and preserve vital functions.
2. Contact security personnel for transportation to the hospital.
3. Notify the Radiation Safety Officer.
4. If possible, while waiting for transportation to the hospital, monitor the injured and remove any grossly contaminated clothing.

### ***Skin Contamination***

External or skin contamination should be treated by washing with mild soap and copious amounts of lukewarm water.

1. Avoid organic solvents or abrasive soaps that make the skin more permeable to the radioactive material.
2. Wash for approximately 2 to 3 minutes.
3. For contaminated hands, give special attention to areas between the fingers and around the fingernails.
4. Repeat no more than 3 or 4 times if contamination persists.
5. If this procedure fails, repeat washing using a soft hand brush.

### ***Contaminated Wounds***

When the skin is lacerated by contaminated glassware or injured by contaminated sharp instruments, immediately rinse the wounded area thoroughly under a stream of lukewarm water.

### ***Ingestion of Radioactive Material***

Immediately notify the Radiation Safety Officer following ingestion or swallowing of radioactive material.

**Section 7**  
Forms

## Section 8

### Radiation Glossary

**Absorbed dose:** The energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the gray (Gy).

**Activity:** Rate of disintegration, transformation, or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).

**ALARA:** Acronym for "as low as reasonably achievable." Make every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the activity is undertaken, taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of ionizing radiation in the public interest.

**Annual Limit on Intake (ALI):** The amount of a radionuclide that would result in a committed effective dose equivalent of 5 rems, or a committed dose equivalent of 50 rems to an organ or tissue. See 10 CFR Part 20 Appendix B.

**Area of use:** A room or suite in which radioactive materials is used. It may have one or more work areas.

**Authorized User (AU):** Any person who is approved by EH&S Radiation Safety to work with radioactive materials.

**Background radiation:** Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. "Background radiation" does not include radiation from source, byproduct, or special nuclear materials.

**Becquerel (Bq):** 1 nuclear transformation per second ( $s^{-1}$ ).

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

**CFR:** Code of Federal Regulations.

**Controlled area:** An area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

**cpm:** Counts per minute. Most radiation detectors display the number of events detected per unit of time. This can be converted to a measure of activity in dpm by dividing by the detection efficiency.

**Curie (Ci):** A unit of activity.  $3.7 \times 10^{10}$  nuclear transformations per second,  $3.7 \times 10^{10}$  becquerels, or  $2.22 \times 10^{12}$  nuclear transformations per minute. The term nuclear transformations is often replaced by the term disintegrations.

**DAC (Derived Air Concentration):** The concentration of a given radionuclide that, if inhaled continuously during the work year, would cause a dose of 5 rem.

**Deep dose:** The dose from external whole body exposure at a tissue depth of 1 cm.

**Deterministic effect:** Health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a deterministic effect. Also called a nonstochastic effect.

**Dose or radiation dose:** Generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined elsewhere in this glossary.

**dpm:** Disintegrations per minute. A measure of activity. See curie.

**Effective dose equivalent or effective dose:** The sum of the products of the dose equivalent to each organ or tissue and multiplied by their respective tissue weighting factors, and then added to the external whole body dose.

**EPA:** US Environmental Protection Agency.

**Exposure:** Being exposed to ionizing radiation or to radioactive material.

**External dose:** That portion of the dose equivalent received from radiation sources outside the body.

**Extremity:** Hand, elbow, arm below the elbow, foot, knee, or leg below the knee.

**FDA:** US Food and Drug Administration.

**Gray (Gy):** SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule/kilogram (100 rads).

**GRSC:** General Radiation Safety Committee.

**High Radiation Area:** An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

**ICRP:** International Commission on Radiological Protection.

**Ionizing radiation:** Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of separating a target atom into an electron and a positive ion. As used in this manual, radiation does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light.

**IRB:** Institutional Review Board (National Institutes of Health). A committee that reviews and approves research projects that involve human subjects.

**Monitoring:** The measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

**NCDRP:** North Carolina Division of Radiation Protection. [www.drp.enr.state.nc.us](http://www.drp.enr.state.nc.us)

**NCRP:** National Council on Radiation Protection and Measurements. A non-profit corporation chartered by Congress to disseminate radiation protection guidance.

**Non-Employee:** This is a person who is not employed by WFUHS/WFU, but who works for another institution. They work under a PI's authorization at WFUHS/WFU on a collaborative effort. This person must abide by the same conditions as listed for "Authorized Users" with the exception of receiving a dosimeter. Since this person is not employed by WFUHS/WFU then he/she must receive a dosimeter, if required, from his/her institution. In addition, this person and their PI must send EH&S Radiation Safety a signed copy of the Non-Employee Agreement form (included in Section 7 of this HANDBOOK).

**Non-stochastic effect:** Obsolete. See deterministic effect.

**NRC:** US Nuclear Regulatory Commission. The federal agency that regulates the use of radioactive byproduct materials. It does not have authority over accelerator-produced radioactive materials or x-rays.

**Occupational dose:** The dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public.

**Photon:** A quantum of radiant energy. In this manual, the term usually means gamma rays or x-rays.

**PO:** Purchase Order.

**Principal Investigator (PI):** Is a faculty member at WFUHS or WFU, who has submitted an application to EH&S Radiation Safety and has been approved by the GRSC to use radioactive materials.

**Public dose:** Dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose or doses received from background radiation, as a patient from medical practices, or from voluntary participation in medical research programs.

**Quality factor:** A modifying factor used to convert dose in rad to dose equivalent in rem. For x-, beta-, and gamma-radiation its value is 1.

**Rad:** Special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram. 100 rads equal 1 gray.

**Radiation area:** An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

**Radiation Safety Inspector:** An EH&S Radiation Safety staff member who has been assigned to a PI for the purpose of auditing the PI's labs.

**RDRC:** Radioactive Drug Research Committee (Food and Drug Administration). The RDRC is chartered by the Food and Drug Administration to review and approve basic research projects involving the administration of radioactive drugs to human subjects. CRSC provides this service.

**Rem:** The special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor. For most forms of radiation, one rem is numerically equal to one roentgen or one rad. One sievert equals 100 rems.

**Restricted area:** An area, access to which is limited by the licensee for purpose of protecting individuals against undue risk from exposure to radiation and radioactive material.

**Roentgen (R):** The special unit of radiation exposure. The amount of exposure that liberates one esu of charge per cc of air. For most forms of radiation, one roentgen is numerically equal to one rem or one rad. Although considered obsolete, this term and its abbreviation are still commonly used.

**RSO (Radiation Safety Officer):** The individual responsible for managing the radiation safety or health physics program.

**Secondary container:** This is a second container that holds the primary container of radioactive liquid to prevent contamination if the primary container has a leak. The secondary container should be big enough to hold twice the volume of the primary container.

**Sievert (Sv):** SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor. 1 sievert equals 100 rems.

**Stochastic effects:** Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

**Survey:** An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

**Temporary Lab Worker:** This is a person who is only going to work in a PI's lab for a short period of time (four months maximum or in a summer program.). This person must abide by the same conditions as listed for "Authorized Users" with the exception of receiving a dosimeter (this person should not work any radioactive materials which would require him/her to receive a dosimeter). The PI must send a signed copy of the Temporary Lab Workers form which lists these temporary lab workers. In addition, these workers must receive a modified training session on radioactive materials, and he/she may then work with radioactive materials but he/she must be supervised by an Authorized User.

**Tissue weighting factor:** A weighting factor for an organ or tissue relating to the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly.

**Unrestricted area:** An area, access to which is neither limited nor controlled by the licensee.

**Work area:** A portion of a room or laboratory suite where radioactive materials are stored or handled. It is usually a single countertop.

**Worker:** An individual engaged in activities that are licensed by a regulatory agency and controlled by a licensee. Classification as a worker does not require an employer/employee relationship. Volunteers, students on clinical rotation, residents, staff, faculty, and visiting scientists and physicians whose duties include work in radiation or radioactive materials areas are considered workers.