Radiation Safety Operations Guide/Manual

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RADIOLOGICAL SAFETY MANUAL

FOREWORD

The use of radioactive materials and devices that produce ionizing radiation is necessary to conduct research at the National Cancer Institute at Frederick (also referred to as the Facility). This manual presents general guidance on the necessary precautions, regulations, and guidelines for the safe handling of such sources.

The use of radioactive materials at the Facility is controlled by the regulations of, and a license issued by, the U.S. Nuclear Regulatory Commission (NRC). The contents of this manual are an integral part of that license and, as such, are enforceable by the NRC. Reference materials in this manual are intended to serve as guidelines for day-to-day operations in the radiological laboratory.

To ensure that radiation sources are being used safely and in a manner that complies with all applicable regulations, a Radiation Safety Committee and a Radiation Safety Office operate at the Facility. Use of radionuclides in the laboratory setting is a privilege granted to authorized users through the NCI-Frederick Radiation Safety Committee. This manual sets forth the responsibilities of that committee and of the Radiation Safety Office. It also details the responsibilities of authorized users who handle radiation sources and identifies the necessary requirements for the safe use of such materials.

All persons working with sources of ionizing radiation at the Facility must be familiar with the contents of this manual and shall abide by the procedures and policies herein established.

This manual is a preliminary introduction to basic requirements for radiation safety in the laboratory. Guidelines for radiation safety and regulations governing isotope use and disposals are constantly being upgraded. All radiation workers are responsible for remaining up-to-date regarding current requirements within NCI-Frederick and knowledgeable of current practices within the field. It is the responsibility of every user to seek out specific training and instruction for procedures employed in his or her laboratory from the supervisor, other trained workers, or the Radiation Safety Office.

Date 3/22/2006

Craig W. Reynolds

Dr. Craig W. Reynolds
Director, Office of Scientific Operations
National Cancer Institute at Frederick

Date 3/22/06

Larry O. Arthur, Ph.D.
Principal Investigator, SAIC-Frederick, Inc.

RADIATION SAFETY MANUAL

I. Administrative Controls

A. Radiation Safety Committee

1. General

The NCI-Frederick Radiation Safety Committee (RSC) was established by the Principal Investigator (PI), Frederick Operations, Science Applications International Corporation (SAIC-Frederick, Inc.), to ensure that all sources of ionizing radiation at NCI-Frederick are used safely and in a manner that complies with all applicable regulations. All rules and polices pertaining to the license and its administration at NCI-Frederick are established by the RSC. The RSC reports to the PI, SAIC-Frederick, Inc., and directs the operation of the Radiation Safety Office (Radiation Safety).

2. Committee Responsibilities

a. Review and approve or disapprove proposed uses of ionizing radiation sources at NCI-Frederick.

b. Establish policy regarding the safe use of ionizing radiation sources.

c. Assure that users of radiation sources are meeting applicable regulations and NCI-Frederick policies.

d. Ensure that all investigators who use ionizing radiation sources are qualified by experience or training to use such sources.

e. Provide technical supervision of the Radiation Safety Office.

f. Review all instances of alleged infractions of regulations or policies and recommend appropriate corrective action.

g. The RSC, through the Radiation Safety Officer (RSO), may suspend any project or procedure that is in violation of the U.S. Nuclear Regulatory Commission (NRC) regulations or NCI-Frederick policies and procedures, or which is believed to be a potential threat to health or property.

h. In the process of reviewing proposed uses of ionizing radiation, the RSC makes no judgment as to the scientific merit of such use. The RSC is concerned only with health and safety.

3. Committee Membership

a. The NCI-Frederick RSC is comprised of representatives from all operating groups within active radiation programs. These representatives are appointed by the PI, SAIC-Frederick, Inc.

b. The Radiation Safety Officer (RSO) is an ex-officio member of the RSC.

B. Radiation Safety Officer/Radiation Safety Staff

1. General

The Radiation Safety Officer (RSO) functions under the technical direction of the RSC and is the operational agent of the RSC. The RSO and Radiation Safety Staff (RSS) are in charge of all day-to-day handling of radioactive materials and other sources of ionizing radiation at NCI-Frederick. All requests for services, purchases, training, and other assistance are directed through this office.

2. Functions and Responsibilities

a. The RSO/RSS formulate and operate a radiation safety program that ensures that the uses of ionizing radiation sources at NCI-Frederick are in compliance with all applicable regulations.

b. The RSO performs and supervises a surveillance program to ensure that all operations at NCI-Frederick involving ionizing radiation are in compliance with applicable regulations and NCI-Frederick procedures and policies.

c. The RSO provides periodic reports to the RSC on the status of the radiation safety program and the surveillance activities.

d. The RSO/RSS approve or disapprove the procurement, shipment, and distribution of all radioactive materials to or from NCI-Frederick.

e. The RSO/RSS receive and inspect all shipments of radioactive materials being delivered to NCI-Frederick.

f. The RSO approves and signs or disapproves all correspondence to the NRC.

g. The RSO/RSS ensure the proper disposal of all radiation waste streams.

3. Authority

    a. The RSO/RSS may enter any laboratory or area where ionizing radiation sources are, or might be, used or stored. This includes areas that might be contaminated.

    b. The RSO may suspend, pending RSC review, any project or procedure that is in violation of NRC regulations or NCI-Frederick policies and requirements, or which is believed to be a potential threat to health or property.

    c. The RSO/RSS may take immediate possession of or establish control over any source of ionizing radiation that is possibly being used or stored in an unsafe manner. Such action is subject to RSC review.

C. Principal Investigator

1. Definition

    A Principal Investigator (PI) is a person who is directly responsible for a specific project under an approved radiation program issued in writing by the NCI-Frederick RSC. The PI has complete authority over all radiation workers (individuals authorized to work with sources of ionizing radiation) in his/her program, regardless of company affiliation or supervisory status.

2. Responsibilities

    a. The PI is personally responsible for the use of ionizing radiation sources possessed under the authority of his/her radiation program.

    b. The PI must ensure that all NCI-Frederick policies, procedures, and regulations are being met. This responsibility includes supervision and training of radiation workers, maintenance of required records, and performance of all required tests.

    c. The PI must provide the RSO with all the information and data requested by the RSO or the RSC.

    d. The PI must ensure that all radiation workers involved with radioactive materials and/or sources of ionizing radiation under the PI's radiation program are using the materials/sources safely and are kept informed of new techniques, procedures, and sources.

    e. Radiation programs are considered "living programs." Prior to making changes to an approved NCI-Frederick radiation program, the responsible PI must first request (in writing) an amendment to the program. Changes to authorized use areas or radioactive materials

being manipulated are examples of the types of changes that require prior approval.

f. The PI may request RSO approval for the appointment of a Radiation Area Supervisor (RAS) to assist the PI in performing the above-mentioned responsibilities.

D. Radiation Area Supervisor

The Radiation Area Supervisor (RAS) is an additional person(s) designated by the PI to assist in the monitoring, training, and record-keeping requirements of the radiation program. The RAS generally has extensive experience and familiarity with the specific procedures being used by a particular lab.

II. Radiation Program Administrative Procedures

In all operations involving sources of ionizing radiation (such as radioisotopes, X-ray machines, electron microscopes, etc.) the written approval of the NCI-Frederick RSC must be obtained prior to the procurement, receipt, installation, operation, or use of such sources. **There are no exceptions to this policy.** A program or project using approved sources of ionizing radiation is hereafter referred to as a *radiation program*.

A. Application Procedure for a Radiation Program

All operations involving sources of ionizing radiation at NCI-Frederick must be performed under an approved radiation program. The proposed Radiation Program PI shall submit for approval a Radiation Program Application to the NCI-Frederick RSC, through the NCI-Frederick RSO. The application contains:

1. **Radiation Program Application Form:** Program application forms for various types of programs can be accessed at the following address:

   http://home.ncifcrf.gov/ehs/ehs.asp?id=35

   It is suggested that the RSO be consulted for comments and suggestions concerning the application prior to the final preparation of the document. The application form contains such information as:

   a. The name of the project wishing to procure radioisotopes or other ionizing radiation–producing sources/machines.

   b. The radioisotope(s), the chemical and physical forms, and the amount of activity (in µCi) to be used during each experiment, as well as the total amount of activity (inventory) of each isotope to be maintained under the program. If other sources of ionizing radiation are to be used (X-ray machines, electron microscopes, etc.), specific

information concerning these sources must be include on the appropriate application form.

c. The location, by building and room number or area, in which the radiation operations are to be performed.

d. A complete list of radiation monitoring and other equipment available for the proposed program, including protective equipment available in authorized use areas.

e. The radiation safety precautions to be used.

f. A description of proposed waste storage space and handling methods.

g. The signature of the PI assuming responsibility over all radiation workers and sources of ionizing radiation within the proposed program.

2. PIs and radiation workers must have appropriate training and experience in the use of the proposed radioactive materials and/or other sources of ionizing radiation. The RSC will evaluate their training and experience relative to the isotopes and possession limits requested in the application for a radiation program. New **Training and Experience Forms (T&E Forms**) for all personnel must be provided in the application packet. T&E Forms for various types of radiation programs can be accessed at the following address:

   http://home.ncifcrf.gov/ehs/ehs.asp?id=35

   The proposed PI must sign all T&E Forms. It is highly recommended that the proposed PI list **all** prior training and experience with radioactive materials (as well as other sources of ionizing radiation) on his/her T&E Form. Approval of a proposed program is highly contingent upon the prior training and experience of the proposed PI.

3. All proposed radiation workers (including the proposed PI) must complete **Radiation Safety Training for New Users**. This training is located at the following address:

   http://home.ncifcrf.gov/ehs/ehs.asp?id=56

   For more information see section III: B: 2 Training. In addition to the above-mentioned training, some equipment-specific training may be necessary (for example, for irradiators, X-ray generators, etc.).

4. Include all radiation protocols associated with the proposed radiation program.

5. It is strongly suggested that the program, for future reference and radiation program renewals, keep a copy of the application on file.

6. The application is to be submitted to the RSO. After review, the RSO will forward the application to the RSC for approval.

7. Prior to RSC review of a Radiation Program Application, the RSO ensures that the facilities and equipment to be used are adequate for the safe use of the radiation sources listed in the application. This inspection may involve a check on ventilation systems, filters, hoods, survey instruments, waste storage techniques, flooring, bench surfaces, shielding, security, handling tools, and safety equipment. The Radiation Safety Office approves the equipment and facilities prior to RSC review and approval of the proposed radiation program.

8. The radiation program will be approved on the basis of the application and the available equipment and facilities, as well as the radiation experience of the proposed operating personnel and responsible investigator.

9. An NCI-Frederick *radiation program number* will be assigned to the program upon approval of the application. **Radiation operations shall not begin until the proposed program has been returned to the requester with an endorsement granting approval for the program.**

10. Any future change in radiation parameters must be approved in writing prior to initiation. These changes include such things as changes in isotopes, increases in activity levels, and substantial changes in protocol design.

B. Principal Investigators with Multiple Radiation Programs

It is possible that a PI may require more than one Radiation Program. When this happens there are certain guidelines that must be followed in order to stay in compliance with NCI-Frederick policy and NRC regulations.

1. Programs can not share isotopes. Only small aliquots may be shared without proper program transfers from Radiation Safety, and only authorized isotopes may be transferred.

2. Authorized radiation workers may manipulate RAM only within their program's authorized radiation areas.

3. Radiation workers on more than one program may only manipulate the isotopes that they are authorized to use on each program within the proper areas associated with each program For example:

   Radiation worker #1 is on program A and B, but is authorized to use different isotopes under each. The isotopes authorized for program A may only be used in program A's authorized radiation areas and vise versa.

C. Program Design

The following should be considered when designing a new radiation program:

1. It is highly desirable to have designated areas within the laboratory where radioactive materials will be manipulated.

2. All work surfaces where radioactive materials are to be used will be constructed with materials that are nonporous and resistant to attack by solutions used in the experimental procedure. The surfaces must be void of open seams and must be easy to clean.

3. Floors in areas where radioactive materials are to be used may not consist of bare concrete or other porous material. The RSO should be consulted concerning adequate floor coverings.

4. Cloth-covered chairs are not permitted in radiation laboratories.

5. Storage areas should be planned to limit the number of freezers/refrigerators that will contain isotopes.

6. The implications of the security requirements must be considered. Licensed material must remain secure at all times against unauthorized removal.

7. The accessibility of office areas and persons likely to visit the laboratory must be considered. Non–radiation workers are limited to lower doses than approved radiation workers.

8. Areas designated for the manipulation of radioactive materials should be clearly marked to ensure that exposures to non–radiation workers are kept as low as reasonably achievable.

9. It is recommended that a RAS be assigned to allow for adequate supervision and the possibility for minor program modifications (pending RSO approval) in the absence of the PI.

D. Program Renewals

1. To ensure accurate and updated program information, Program Renewal Applications must be submitted on a periodic basis. The process will be initiated by the RSS.

2. The RSS will supply the program with a Radiation Program Renewal Application and a Radiation Program/Personnel Comprehensive Report. This report contains program-specific information that is to be reviewed by the program PI for accuracy.

3. Each person listed on the renewal application must fill out a new Radiation Training and Experience Form, which will be included in the Radiation Program Renewal Application.

4. The PI must also include a copy of the signature sheet from the Protocol Specific Training document (PST) entitled "Working Safely with Radioactivity," containing each radiation worker's signature. Copies of current protocols must also be included with the renewal application.

5. For radiation-producing machines (EM/X-ray) and irradiator programs, dated documentation of successful completion of equipment-specific training must be included for each person listed on the renewal application.

6. The appropriate signatures must be obtained as requested on the application forms.

7. The completed renewal application is to be returned to the RSO within two weeks. Any amendments to the program will be made as appropriate, and a confirmatory memo will be sent back to the PI/RAS, indicating that the requested changes have been made to the Program.

E. Amendments to the Radiation Program

1. Any request for amendment to a radiation program must be submitted in writing to the RSO. Only the PI or the RAS has the authority to request an amendment.

2. A radiation program must be amended, in writing, when any of the following takes place:

   a. Radiation workers are added or removed.

   b. Changes occur in radioisotopes.

   c. Activity usage level increases.

d. Substantial changes are made in the protocol design.

e. Rooms are added to or removed from the radiation program.

3. A confirmatory memo will be sent back from the RSO indicating that the requested changes have been made to the program.

F. Required Records

The PI is responsible for the maintenance of the following required records:

1. Receipt, use, and disposal of radioactive materials:

   a. Radioactive Material Accounting Record (RMAR) sheets represent the lab record of active inventory.

   b. Each radiation program is required to maintain an accurate inventory of the radioactive material possessed by the program; to maintain this inventory within current program limits; and to reconcile this information with the information contained in the Six-Month Inventory Questionnaire that is distributed by the Radiation Safety Office in January and July of each year.

   c. Periodic checks of laboratory radioactive material inventory should be made to eliminate outdated stocks.

   d. Log sheets (Dry, Liquid) on waste containers must accurately reflect container contents and represent the record of radioactive material disposed from inventory.

2. Transfer or shipment of radioactive materials:

   a. Transfers of radioactive material to another radiation program must be recorded on the RMAR and cleared with the RSO/RSS in advance.

   b Any shipment of radioactive material off-site must be done through the RSO/RSS.

3. Laboratory monitoring tests/Contamination test results:

   a. Contamination monitoring (radiation surveys) should be conducted after each manipulation of radioactive material. At a minimum, contamination monitoring must be performed and documented on a monthly basis. Be sure to use the appropriate monitoring technique for the type of radioactive material used. Radioactive contamination must be cleaned to levels that are as low as reasonably achievable.The

maximum permissible contamination levels for alpha and beta/gamma radiation are 10 and 500 disintegrations per minute (dpm), respectively, for an area of 100cm^2. These limits are for removable contamination. If the contamination is not removable, then the limits are 300 dpm/100 cm^2 for alpha activity and 0.1 millirem/hr for beta-gamma radiation For more information see section IV: G. Surveys and Contamination Control.

b. Documentation of contamination monitoring must be maintained on file within the program. Contact the RSO prior to disposal of any contamination monitoring records to ensure record retention periods meet requirements.

4. Protocol-specific training:

a. Protocol-Specific Training Documents (PSTD) must be kept on file within the program. The documents must include a signature sheet containing the signatures of all radiation workers trained on the radiation protocols used within the program.

b. The PSTD is the responsibility of the PI and must be thoroughly reviewed with each new radiation worker, regardless of prior radiation training.

5. Documentation for the current radiation program and all applications for and amendments to that program.

G. Termination of a Radiation Program

1. Whenever a radiation program is to be terminated or an area is to be returned to non-radiation use, the RSO must be notified. A radiation program is not terminated until the RSO/RSS determines that:

a. All sources and contamination have been removed.

b. All warning signs have been removed.

c. The responsibility for existing radioactive sources has been properly transferred.

d. All required records and other radiation protection matters have been completed and reviewed.

e. The PI has received a written statement from the RSO, confirming that the radiation program has been terminated.

H. Disciplinary Action

1. The RSC has the authority to terminate any radiation program if the PI or anyone under the PI's supervision fails to comply with NRC regulations, NCI-Frederick polices and procedures, and/or conditions specified in the approved radiation program.

2. The RSO or the RSC Chairman may temporarily suspend any worker or program that is not in compliance with the applicable regulations or policies.

3. The RSC may alter an approved radiation program in accordance with applicable regulations or policies.

4. The RSC will provide a means of appeal to the PI, SAIC-Frederick, Inc., for any PI who does not agree with the decisions of the RSC.

III. Radiation Worker

A. Definition

A radiation worker is a person who voluntarily performs work involving sources of ionizing radiation. Such a person shall know that the work involves the use of ionizing radiation before the work commences. A radiation worker works under the supervision of the PI or RAS, regardless of company affiliation or supervisory status.

B. Training

1. Permission to use radioactive materials and/or sources of ionizing radiation at NCI-Frederick is contingent upon the completion of all required radiation safety training courses. Approval to use radioactive material must be granted by Radiation Safety prior to use.

2. Proposed radiation workers must successfully complete the **Radiation Safety Training for New Users** computer-based training (CBT) course before they can become authorized users of radioactive materials and/or sources of ionizing radiation. This course covers aspects of radiation operations, regulations, and policies required at NCI-Frederick, as well as radiation physics, and general safety. This training is located at the following address:

http://home.ncifcrf.gov/ehs/ehs.asp?id=56

To get your user name and password, you must first click on "Start Training," then "I need an account." This will open an e-mail application that is used to request user name and password information.

3. Approved radiation workers must also complete **Radiation Safety Refresher Training** every two years. The Radiation Safety Office will send a memo with training login number and radiation program number to radiation workers when training is due. This training is located at the following address:

   http://home.ncifcrf.gov/ehs/ehs.asp?id=34

4. In addition, protocol-specific training is required. The Protocol-Specific Training Document (PSTD) maintained on file in each radiation program outlines specific safety procedures for each protocol carried out in that radiation program. Proposed radiation workers, regardless of the worker's prior experience and background, must thoroughly review this document with their PI or RAS and confirm their review and understanding of the material by signing the signatures sheet attached.

C. General Requirements

1. Each radiation worker shall have ready access to the information contained within this manual and shall be familiar with the requirements specified in the manual.

2. Based on previous experience, radiation workers will be assigned either "supervised" or "unsupervised" status. Radiation program PIs must ensure that radiation workers who have been assigned "supervised" status are appropriately supervised during the first six months of radioactive material use.

3. A radiation worker shall manipulate ONLY up to the maximum activity and ONLY the radioisotopes for which he/she is authorized. If usage or limits of radioisotopes need to be updated, a memo requesting these changes must be submitted to the RSO from the radiation program's PI or RAS.

4. If a radiation worker is on more than one radiation program they may only manipulate authorized isotopes and RAM within the proper program and authorized areas of that program

5. A radiation worker shall not use sources of ionizing radiation in a manner that violates NRC regulations, NCI-Frederick policies or procedures, or the conditions specified in the radiation program issued by the RSC.

6. A radiation worker shall take all necessary actions that will maintain radiation exposures **as low as reasonably achievable** (ALARA). For more information on ALARA see section IV: C. ALARA/Time, Distance, Shielding.

7. A radiation worker shall seek the assistance of the PI or the RSO/RSS whenever there is any doubt or uncertainty about a procedure or policy concerning sources of ionizing radiation.

8. A radiation worker will immediately report any accident or unusual occurrence involving ionizing radiation sources. This report should be made to the PI or the RSO/RSS.

9. A radiation worker shall not purposefully defeat, disengage, or deactivate any device designed to provide a safe environment with sources of ionizing radiation.

10. A radiation worker shall comply with all approved radiation safety procedures.

11. A radiation worker shall report to the PI or the RSO/RSS all uses of radiation sources that are not in accordance with applicable regulations, policies, procedures, or conditions of the radiation program.

12. A radiation worker must visit the Radiation Safety Office during the NCI-Frederick termination process. Please turn in any dosimetry badges during this time.

D. Practical Radiation Protection

1. Wear appropriate personal protective equipment (PPE) consisting of fully fastened lab coat, protective eyewear, and gloves when manipulating radioisotopes or sources of ionizing radiation.

2. Wear assigned radiation dosimeter(s) when working with sources of ionizing radiation.

3. Acquire information on applicable shielding and handling practices **before** using an unfamiliar radioisotope.

4. Monitor hands, shoes and clothing frequently for evidence of contamination. Decontaminate as appropriate. Thoroughly wash hands after manipulating radioactive materials.

5. Cover surfaces in the immediate vicinity of work involving radioactive materials with plastic-backed absorbent paper, plastic side down.

6. Properly label all radioactive materials and display proper signage designating radioisotope usage in the laboratory.

7. Maintain complete and accurate records of all radioisotopes received, used, and disposed of.

8. Ensure that the laboratory is surveyed for radiation contamination frequently, and ensure that a formal monthly contamination survey is performed and documented within all authorized use areas. For more information see section IV: G. Surveys and Contamination Control.

9. Do not eat, drink, or pipette by mouth in any laboratory area.

10. Do not store food or drink in any area in which radioactive materials are authorized to be used or stored.

11. Dispose of radioactive waste only in designated, labeled, and appropriately shielded radioactive waste containers.

12. Do not dispose of radioactive waste down drains or sinks at the NCI-Frederick. ANY RADIATION ABOVE BACKGROUND LEVELS FOUND IN SINKS AT NCI-FREDERICK IS IN DIRECT VIOLATION OF NRC LICENSE CONDITIONS.

13. Perform work with volatile radioisotopes or with other radioactive materials that may become airborne in a hood approved for low-level radioactive materials. Contact Radiation Safety **before** beginning any work involving unbound (free) radioactive iodine. Specific hood requirements must be met before performing iodinations.

14. Report accidental inhalation, ingestion, injury, or spills involving radioactive materials to the appropriate PI/RAS and to the RSO immediately.

15. Maintain constant surveillance of unsecured radioactive materials at all times. Radioactive material that is not in use must be secured from unauthorized removal or access at all times.

E. Ionizing Radiation Theory

1. Definition

Ionizing radiation has the ability to remove electrons from atoms, creating ions; hence the term "ionizing radiation." The result of ionization is the production of negatively charged free electrons and positively charged ionized atoms.

2. Radioactive materials have an associated half-life, or decay time characteristic of that isotope. As radiation is emitted, the material becomes less radioactive over time, decaying exponentially. Some radioisotopes have long half-lives; for example, C-14 takes 5,730 years for any given quantity to decay to half the original amount of radioactivity. Other radioactive materials have short half-lives; P-32 has a two-week half-life, and Tc-99 has a half-life of six hours.

3. The equation used to calculate radioactive decay is:

$$\mathbf{A = A_0\, e^{-kt}}$$

Where:

A = current amount of radioactivity
A_0 = original amount of radioactivity
e = base natural log (approximately 2.718)
k = the decay constant = 0.693/t1/2 (where t1/2 = half-life)
t = the amount of time elapsed from **A_0** to **A**

4. Knowing the radioactive decay rates/half-lives of the radioisotopes you are working with helps to eliminate outdated stocks.

5. If contamination is "non-removable," the radioactive decay equation can help determine when radiation levels will be indistinguishable from background.

F. Radiation Units

Two types of units are used for radiation: units of activity and units of exposure (dose). Units of activity quantify the amount of radiation emitted by a given radiation source. Units of exposure quantify the amount of radiation absorbed or deposited in a specific material by a radiation source.

1. Units of Activity

   a. The unit of activity for radiation is the curie, or Ci. The curie is an amount of radioactive material emitting 2.22×10^{12} disintegrations per minute (dpm). Most of these measurements are made with a liquid scintillation counter, gamma well counter or Geiger-Mueller survey meter (GM).

   b. NCI-Frederick laboratories routinely use only millicurie (mCi) or microcurie (μCi) amounts of radioactive materials.

2. Units of Exposure

a. The rad (radiation absorbed dose) and the rem (radiation equivalent man) are the two main radiation units used when assessing radiation exposure.

b. The rad is the unit of absorbed dose and refers to the energy deposition by any type of radiation in any type of material.

c. The rem is the unit of human exposure and is a dose equivalent. It takes into account the biological effectiveness of different types of radiation.

3. Maximum Permissible Exposure Rates

a. An *unrestricted area* is any area in which non–radiation workers can or may be found. The maximum permissible exposure rate anywhere in an unrestricted area is 0.25 millirem per hour. All reasonable efforts should be made to keep exposure rates in unrestricted areas below this limit.

b. A *restricted area* is an area in which only radiation workers are allowed. The maximum permissible exposure rate anywhere in a restricted area is such that no individual will receive in a calendar quarter a dose in excess of:

(1.) 1.25 rems to the whole body, head and trunk, active blood-forming organs, or gonads

(2.) 3.75 rems to lens of the eye

(3.) 12.5 rems to the extremities

(4.) 12.5 rems to the skin of the whole body.

c. A *radiation area* is any area accessible to personnel in which the radiation dose rate is such that a major portion of the body could receive in excess of 5 millirems per hour.

d. A *high radiation area* is any area accessible to personnel in which the radiation dose rate is such that a major portion of the body could receive a dose in excess of 100 millirems per hour.

e. An *airborne radiation area* is any area in which the airborne radioactivity exceeds the limits prescribed in Appendix B, 10 CFR 20 of NRC regulations, or where concentrations, averaged over the number of hours in any week during which individuals are present in

the area, exceed 25 percent of the limits specified in Appendix B, 10 CFR 20.

G. Biological Effects of Radiation

1. Radiation-induced injury is mainly caused by ionization within the tissues of the body. Ionizations and excitations are produced in either biological macromolecules or in the medium in which the cellular organelles are suspended when radiation interacts with a cell.

2. There are two primary exposure types connected with work involving radioactive materials: external and internal exposure to radiation.

3. *External exposure*: Arises when radiation from a source external to the body penetrates the body and causes a radiation dose. These exposures are dependent upon both type and energy of the radioactive material.

    a. Beta particles: Most do not normally penetrate beyond the skin, but when sufficiently intense, they can cause skin and/or eye damage. Very energetic beta particles, such as those emitted by P-32, can penetrate several millimeters into the skin. Shielding is needed, typically a 3/8 inch thick sheet of Plexiglas, to reduce external radiation exposure.

    b. Alpha particles: Rarely penetrate the outer dead layer of skin. Alpha particles are capable of traveling only a few inches in air due to higher mass, slower velocity, and greater electrical charge than beta particles.

    c. Gamma and X-rays: Both types have no mass, are very penetrating, and usually must be shielded.

4. *Internal exposure*: Arises when radiation is emitted from radioactive materials present within the body. Radiation uptake may occur through one of three routes of entry; inhalation, ingestion, and skin contact. Internal exposures can occur from all forms or radiation.

5. Internal exposures are most likely to occur when radioactive material becomes airborne; is inhaled and absorbed by the lungs and deposited in the body; is present in contaminated food, drink, or other consumable products and is digested; is spilled or aerosolizes onto the skin and is absorbed or enters through breaks in the skin; or via contaminated hands, with subsequent eating or rubbing of eyes.

IV. NCI-Frederick Policies and NRC Regulations

A. Food and Drink Policy

1. Never introduce any food or drink into a posted radiation area, even for temporary storage. This includes desk space if it is located in a laboratory that is authorized for radioactive material use.

2. Applying cosmetics, chewing gum, or eating candies, cough drops, or other such consumable items is not permitted in any radiation areas.

3. Never pipette by mouth.

4. Never use a microwave oven located in a radiation area for heating food or drinks.

B. Radioactive Material Sink Policy

1. NO radioactive material may be disposed through the sanitary sewer. Any radioactivity above background levels in any sink at NCI-Frederick is in direct violation of NRC license conditions.

2. Do not clean or rinse any contaminated equipment in the sink. Contaminated equipment must be rinsed off into an appropriate container and the waste water collected for disposal as aqueous radioactive waste, as instructed in section IV: M (Disposal of Radioactive Material) of this manual.

C. ALARA/Time, Distance, Shielding

NCI-Frederick fully supports the concept that all radiation doses should be as low as reasonable achievable, or ALARA, for all employees, visitors, and students. This implies that no dose should be acceptable if it can be avoided. NCI-Frederick's ALARA program depends on the cooperation of all authorized radiation users, as well as their supervisors and PIs.

One can maintain exposures ALARA by practicing the following basic principles of radiation protection:

1. External Radiation Protection:

   a. **Minimize time of exposure**. The shorter the time you spend in a radiation field, the lower the dose your body absorbs. Perform the experiment or the procedures as quickly as possible without increasing the probability of an accident or spill.

   b. **Maximize the distance from the source**. For all types of radioactive materials, increasing the distance from the source of radiation will decrease the potential hazard and level of the dose received.

i. Beta rays of a given energy level have a finite range in air. The range of beta particles in air is approximately 12 ft/Mev. The chart below list maximum particle range for some common isotopes used at NCI-Frederick:

Isotope	Maximum Energy in Mev	Maximum Range
3H	0.0186	<3 in.
C-14	0.156	22 in.
S-35	0.168	2 ft.
P-32	1.71	20 ft.

ii. Gamma and X-rays follow the inverse square law. For example, doubling the distance from a radiation source will result in one-fourth the exposure in the same amount of time. One practical implementation of this principle is using remote handling devices such as forceps, tongs, tube racks, etc., to minimize direct contact with large sources of gamma-emitting material.

c. Shield the radiation source properly. Proper shielding will reduce almost all radiation emissions in the common laboratory setting.

i. For low-energy beta emitters (H-3, 14-C, 33-P, and S-35): Shielding is not normally required because their emissions are too weak to penetrate clothing or the surface layer of the skin. However, common safety practices include using absorbent paper, carefully closing all containers, etc.

ii. For high-energy beta emitters (P-32): P-32 is most effectively shielded with 3/8-inch thick Plexiglas shields. Lead is not to be used with this isotope because of the potential generation of bremsstrahlung X-rays.

iii. For gamma and X-rays (Cr-51 and I-125): Low-energy chromium and iodine can be shielded with 3/8-inch Plexiglas, whereas higher concentrations may require thin lead foil that can be manipulated to cover the containers.

2. Internal Exposure Protection

a. Inhalation: A chemical fume hood or biological cabinet that has been certified for radioactive materials work is highly recommended when using potentially volatile compounds. Use centrifuges, vortex mixers, shakers, etc., in such a way that production of and exposure to radioactive aerosols is minimized.

b. Puncture: Dispose of syringes and pipettes promptly and in appropriate containers. Do not attempt to recap needles after use. Guard against glass breakage and puncture injury during use and disposal.

c. Ingestion: Never introduce any food or drink into a posted radiation area.

d. Absorption: Use measures to prevent contamination of skin and eyes such as lab coat, gloves, and eye protection. Eye protection is especially important if you wear contact lenses, since some lenses will absorb and concentrate radioactive materials. Wash hands after manipulating radioactive materials, and monitor hands for contamination, especially before eating or smoking, and prior to leaving the radiation area.

D. Special Procedures and Bioassays

1. Iodinations

a. Radiation workers who wish to perform an iodination (work involving "free" or "unbound" radioactive iodine) must notify Radiation Safety **prior to** performing the experiment.

b. Radiation workers performing iodinations will be required to obtain a thyroid scan within 72 hours of the procedure (waiting at least 6 hours for distribution of the majority of the iodine to the thyroid). A baseline scan shall be performed on new users prior to beginning work with radioactive iodine.

c. The iodine concentrations in the breathing zone air of the user and in the exhaust air from the hood will be measured whenever an iodination procedure is performed. The concentrations are determined by passing a known air volume through activated charcoal-filled tubes. The radiation worker performing the iodination is responsible for picking up the breathing zone tube and Iodination Schedule Form, from Radiation Safety, prior to staring the experiment. The RSO/RSS will be responsible for collection of the tubes and their assay. The

following information will be provided to the RSO/RSS with each sampling tube:

i. The rate at which air was drawn through the tube in liters per minute

ii. The sampling time interval

iii. The iodine isotope used in the experiment

iv. The date of the procedure

v. The name(s) of the employee(s) performing the iodination.

d. Iodinations must be performed in a chemical fume hood or an approved biological safety cabinet equipped with a charcoal filter. Hoods to be used for iodinations must be pre-approved by Radiation Safety. Radioactive iodine is not to be used in any activity levels in air circulation hoods.

e. The RSO will determine the type of hood or cabinet, airflow requirements, and filtration requirements.

2. Thyroid Scans

a. Radiation workers authorized to use radioactive iodine (bound or unbound) must receive a baseline thyroid scan prior to manipulating radioactive iodine. The RSO/RSS will contact new employees to schedule a scan.

b. Radiation workers performing iodinations must receive a thyroid scan in accordance with section 1.b. above.

3. Urine Bioassays

a. Radiation workers performing high-activity experiments involving the use of 10 mCi or more of H-3, C-14, S-35, P-33, or P-32 at one time must submit a urine bioassay sample between 12 hours and 72 hours after performing the experiment. Bioassays for experiments involving 10mCi or more of other radionuclides will take into account biological decay, and will be performed in a time frame that ensures effectiveness for assessing potential body burden. The RSO/RSS should be notified of the expected use and approximate time of use in advance, whenever possible.

b. Urine bioassay specimen cup(s) and the Mandatory Urine Bioassay Memorandum requesting information about the experiment such as: isotope, activities, time, etc., will be delivered to the radiation worker along with the radioisotope.

c. Declared pregnant radiation workers, certain animal facility radiation workers, and NCI-Frederick waste management staff must submit monthly urine bioassay samples. A memo and specimen cup will be mailed from Radiation Safety to each radiation worker on the Urine Bioassay Program at the beginning of each month.

Failure to submit a required urine bioassay sample may result in suspension of isotope-use privileges.

4. Declared Pregnant Workers

a. Pregnant radiation workers may "declare" their pregnancy. If one chooses to declare one's pregnancy, it must be done in writing to Occupational Health Services (OHS) using the **Declaration of Pregnancy/Pregnancy Interview Certificate**

b. A member of the Radiation Safety Office will be contacted by OHS to be present during the pregnancy interview. The RSO/RSS can answer questions concerning the declaration process and will distribute a folder containing the following information.

i. NRC Regulatory Guide 8.13
ii. Bioassay Declaration – to be signed and returned
iii. Form to withdraw declaration

c. If the radiation worker chooses to declare her pregnancy (she may choose not to if she wishes), a fetal monitoring badge (if applicable) will be provided, and necessary bioassays will be determined based on isotope type and usage indicated on the individual's Radiation T&E Form(s).

d. Declared radiation workers approved for any isotope use must submit monthly urine bioassays and those approved for radioactive iodine use must obtain a monthly thyroid scan. Radiation Safety will send memos out at the beginning of each month as reminders of these bioassay requirements.

e. Separate monthly exposure reports from our dosimeter provider will be sent to the individual. The dose to the embryo/fetus will be limited to 0.5 rem. The lower dose limit for the embryo/fetus should remain in effect until the woman withdraws the

declaration in writing or the woman is no longer pregnant. If a declaration of pregnancy is withdrawn, the dose limit for the embryo/fetus would apply only to the time from the estimated date of conception until the time the declaration is withdrawn. If the declaration is not withdrawn, the written declaration may be considered expired one year after submission.

f. Radiation Safety will notify the radiation worker when any exposure has been detected by a fetal monitoring badge or during a bioassay. An investigation of possible causes will be pursued to determine how to prevent future exposures and to determine whether the reported exposure is valid.

g. Radiation Safety will make every effort to maintain confidentiality of the radiation worker during the pregnancy.

F. Personnel Monitors

1. Radiation workers who are authorized to manipulate radioisotopes that emit high-energy betas, gamma rays, or x-rays will be issued dosimetry device(s). These devices are designed to measure your radiation exposure. The RSO, with the approval of the RSC, may permit exceptions or may initiate additional requirements to this policy.

2. Radiation workers who are authorized to manipulate 10 mCi or more of P-32, and workers who perform iodinations will be issued a thermoluminescent dosimeter (TLD) ring badge.

3. Ring badges will be issued to other radiation workers (such as those who belong to X-ray programs) on a case-by-case basis. Risk will be the determining factor for issuance of these badges.

4. RSS personnel will change all dosimetry devices on a quarterly basis (with the exception of a few radiation programs and fetal monitoring badges, which are changed on a monthly basis). Dosimetry devices should be kept attached to the lab coat or in the general vicinity of the radiation worker's personal laboratory space, **away** from any radiation sources.

5. It is asked that the location of dosimetry devices be consistent to assist RSS in locating the devices when needed, and to help reduce the number of "lost" devices

6. A Radiation Dosimetry Report from our dosimeter provider will be sent to the radiation program's PI or RAS each quarter. All "badged" radiation workers have access to their personnel exposure information listed on these

reports. The results from a dosimetry badge report become a part of a person's permanent record reflecting lifetime exposure.

7. An Annual Dosimetry Monitoring Report will be made available to all "badged" workers in March/April of each year. This report provides permanent to date exposures (in Rem) and personal information used to identify each worker and will be available from the Radiation Safety Office by personnal request. For general information regarding these reports please click on the following link:

   Annual Dosimetry Report Information

8. RSS will notify the radiation worker when an exposure above 130 mrem is reported. An investigation of possible causes will be pursued to determine how to prevent future exposures and to determine whether the reported exposure is valid.

9. Review of NCI-Frederick radiation exposure monitoring results for the past 20 years indicates that occupational radiation exposures nearing regulatory limits are not likely. In fact, most occupational radiation exposures received by radiation workers at NCI-Frederick are below the minimum detection capabilities of the exposure monitoring devices currently in use.

F. Radioisotope Storage and Security

THE RULE: All radioactive material and ionizing radiation sources must be kept secured from unauthorized removal or under constant surveillance at all times!

1. Unless under direct and immediate observation, storage units containing radioactive materials shall REMAIN LOCKED during working hours. This applies to refrigerators/freezers, cabinets, or lock boxes containing stock isotopes, as well as to waste containers. Otherwise, the room or area must be secured.

2. All waste receptacles and storage units (e.g., freezers) containing radioisotopes or other sources of ionizing radiation that cannot be secured shall be located in areas where access can be controlled (e.g., laboratory rooms, equipment rooms, anterooms).

3. Untended laboratory rooms containing unsecured radioactive material or other sources of ionizing radiation must be locked, even during daytime hours.

4. Corridors are not secured areas. Therefore, using and storing radioactive materials or other sources of ionizing radiation in these areas is prohibited.

5. Persons unknown to the occupants of an area where radioactive materials or other sources of ionizing radiation are used or stored should not be permitted into the area without proper identification and a legitimate reason for entry.

6. All radioactive materials must be secured from unauthorized removal before leaving the area at the end of the day.

7. The above regulations shall be enforced at the laboratory and/or program level, regardless of the security status of the building.

Violations of radioactive material security policies may result in suspension of radioactive material use privileges for the entire radiation program.

G. Surveys and Contamination Control

1. Authorized radiation programs must document the performance of a contamination survey **at least once a month** regardless of the quantities of radioactive material utilized within the month. All authorized use areas within the radiation program must be included in the survey.

2. It is good practice to monitor for radioactive contamination whenever radioactive materials are used or whenever there is reason to suspect contamination. It is suggested that contamination surveys be conducted each time a radioactive isotope is manipulated.

3. Surveys are normally performed by wiping a surface of the known area with Parafilm M and then determining the activity on the film with a liquid scintillation counter (LSC). A GM counter may aid in performing the survey for high-energy beta emitters such as P-32 or CR-51. Radioactive contamination must be cleaned to ALARA levels. After decontamination, the area should be re-swiped, and the re-swipe data should be documented with initial survey results. The decontamination action level for NCI-Frederick is 500 dpm/100 cm^2 removable contamination for beta/gamma and 10dpm/100cm^2 for alphas..

4. All documented surveys must include:

    a. A way of indicating swipes/survey points (such as a diagram/map showing the location of benches, desks, sinks, and hoods) within all authorized use areas belonging to the program. Each swipe/survey point taken should be numbered on the diagram/map so that any contaminated areas in need of decontamination can be readily identified. Areas tested should be representative of areas where contamination might be expected as well as some areas where contamination would not be expected.

b. A positive (sealed source H-3 and/or C-14 standards) and negative (background standard) control shall be run along with the swipes to determine efficiency for counts per minute (cpm) to dpm conversion. The positive and negative controls must be included on the LSC survey printout each month.

c. Records are to be kept on both positive and negative results. All positive contamination must be properly cleaned, re-swiped, and re-read on the LSC with a printout attached to the original results.

d. Diagrams/maps and swipe results are to be properly dated and kept on file in the laboratory for review by RSO/RSS. It is recommended that all authorized radiation workers know where this file is kept.

5. Radioisotope laboratories will be equipped with radiation monitors and/or survey instruments suitable to detect the type of radioactive materials being used in the laboratory. The RSO will determine the type and number of such instruments.

H. Radiation Safety Surveys and Quarterly Program Records Check

1. Monthly radiation surveys performed by the Radiation Safety are done for the purpose of maintaining a broad surveillance program at the facility level, and to alert the individual programs to potential problem areas if a contamination or deficiency is found. These surveys are neither frequent nor sufficiently thorough enough to serve as the only laboratory monitoring, which is why the programs' staff members must also perform their own contamination surveys.

2. Contamination swipe tests, as well as survey meter tests where appropriate, will be performed and documented by RSO/RSS for each radiation program at NCI-Frederick on a monthly basis. Radiation Safety will check for:

a. Labeling—Entrance to room
b. Labeling—Refrigerator/freezer/storage area
c. Labeling—Waste containers
d. Labeling—Radioactive materials
e. Labeling—Hoods
f. Labeling—Contaminated equipment
g. Use of absorbent paper as needed
h. Routine use of shielding as needed
i. Routine use of PPE (lab coat, gloves, eyewear)
j. Use of dosimeter as needed
k. No food or drinks in lab
l. Survey meter available/current calibration/batteries ok
m. Security

n. Other problems

3. Maximum permissible removable contamination level is 500dpm/100cm^2 or 10dpm/100cm^2 for beta/gammas and alphas respectively. If any swipe results meet or exceed these levels, they will be re-read to check for accuracy by RSS. The staff, via phone message as well as survey report, will report contaminations to the respective laboratory personnel.

4. All contaminations found by the RSO/RSS must be cleaned and re-swiped by laboratory personnel belonging to the radiation program in which the contamination was found. The radiation program PI/RAS is then responsible for making sure that the Contamination Clean-up Sheet that is attached to the Monthly Survey Report is properly filled out with post clean-up dpm results. The Contamination Clean-up Sheet must be forwarded back to the RSO/RSS within 72 hours (3 days) of receipt.

5. Any deficiencies noted by RSS will be addressed in the Monthly Survey Report as well. All deficiencies will be noted on a Deficiency Memo. A written response to the Deficiency Memo, indicating corrective actions taken, must be forwarded back to the RSO/RSS within 5 days of receipt.

6. Approximately four times per year, records checks will be performed by RSS. Records checks will be performed during routine surveys. RSS will check all documented monthly surveys performed by the program and the program's radioactive material inventory.

    a. RSS will verify that the program is documenting a contamination survey for all authorized areas on the program at a minimum of once each month. RSS will also verify that any contaminations found by the program are appropriately decontaminated and that positive and negative controls are documented with each survey.

    b. Radioactive Material Accounting Records (yellow sheets) will be checked to ensure the use of licensed material is being accurately recorded.

I. Procurement of Radioactive Material

The procurement of radioactive material and machines capable of producing ionizing radiation will be accomplished only with the prior approval of Radiation Safety. Only authorized radiation workers within approved radiation programs may request a procurement of radioactive material. These materials and equipment fall into the following general categories:

a. Radioactive material regulated by the NRC and requiring a radioactive material use license issued by the NRC.

b. Radioactive material procurable under a license issued by the NRC.

c. Apparatus and equipment capable of, or containing materials capable of, producing ionizing radiation. These include X-ray machines, particle accelerators, certain cathode-ray tubes, electron microscopes, and many other devices.

2. The procurement of items listed above will be initiated only with prior approval of the RSO/RSS. Information concerning the procedure for the procurement of items in the above categories is available from the Radiation Safety Office.

3. The RSO/RSS are notified immediately by personnel working in the receiving warehouse when a shipment containing radioactive materials arrives at the facility. The RSO will ensure that licensed radioactive material is retrieved, inventoried, and delivered to the end user in compliance with NRC regulations and NCI-Frederick policies and procedures.

4. Authorized radiation workers can only order those materials that they are authorized to work with, as stated on their T&E Form.

5. Only authorized personnel (usually administrative) are able to order radioisotopes for a program. Please be sure that you know who this is in your program. When ordering radioactive material, the following information must be provided to the Purchasing Department:

a. The name of the authorized radiation worker

b. The radioisotope (P-32, S-35, etc.)

c. The compound (dATP, methionine, etc.)

d. The activity (mCi)

e. The catalog number

f. The name of the company (ICN, NEN, etc.)

g. The NCI-Frederick radiation program number (75-01,85-01,etc)

6. Please be sure to let your "purchasing person" know that *the order is for radioactive material!*

7. RSS will approve (or disapprove) all radioactive material orders on-line. If there is any information missing from the request, RSS will contact the requester for clarification before approving. Therefore, please be sure all information is complete and accurate, to avoid delays.

J. Radioisotope Inventory

1. Upon receipt of radioactive material, the RSS will perform a contamination check and prepare the appropriate forms for transfer to the authorized recipient.

2. Every effort will be made by the RSS to deliver the material to the requester within four hours of receipt of the material by the facility.

3. Transfer of material from the RSS to the radiation program requires a signature, date, and time of receipt to be entered on the accompanying Radioactive Material Accounting Record. These "yellow sheets" represent the program's record of active inventory.

4. The Radioactive Material Accounting Record must be properly updated each time a radioisotope is used by recording the following:

    a. Date

    b. Amount (volume) removed

    c. Amount (volume) remaining

    d. Signature of radiation worker

5. Each radioactive material must have an associated Radioactive Material Accounting Record. These "yellow sheets" should be readily available to ALL radiation workers within the radiation program. Remember, all radioactive material must be secured against unauthorized removal within the program's authorized radioactive material use area.

6. When an isotope is consumed or no longer wanted, the empty stock vial or remaining isotope is to be properly disposed of as radioactive waste (please see section IV:M [Disposal of Radioactive Material] of this manual for details regarding disposal). The completed "yellow sheets" are to be returned to Radiation Safety after disposal.

7. It is important to keep accurate records of receipt and use of radioactive materials for review by the RSO or the NRC.

8. RSS will perform biannual inventory checks, or a "six-month inventory." The six-month inventory is usually performed each January and July. RSS will send out an e-mail prior to the actual inventory start date requesting the return of all yellow sheets associated with properly disposed/consumed radioisotopes. Early return of these yellow sheets will facilitate the six-month inventory process.

9. During the six-month inventory process, a Radioisotope Inventory Questionnaire along with a Program Review will be sent to all isotope specific radiation programs. The questionnaire and program review are to be properly completed and signed by the PI or RAS within two weeks of receipt. Isotope specific programs may use this time to make any corrections/changes to their programs. The following information is to be provided regarding inventory:

    a. Compound

    b. Current volume (in µl)

    c. Current location of material (building/room)

10. Radiation Safety will perform a physical inventory inspection on randomly selected radiation programs. Programs selected will be contacted by RSS to set up a time for the inspection. Updated inventory information will be compared with actual isotope stock, storage, location, and associated yellow sheets.

K. Inter-Program Inventory Transfers/Shipment of RAM

1. **Transfer of radioactive materials requires prior approval by the Radiation Safety Office. This includes transfer between authorized radiation programs as well as transfer (shipment) to off-site locations.** Transfer of any amount of radioactive material without prior approval or to unauthorized areas is strictly prohibited.

2. Shipments of radioactive material from NCI-Frederick **must be approved in advance** through the Radiation Safety Office. This is done to ensure conformance with NRC, U.S. Department of Transportation, and other shipping regulations as well as with the Radiation Safety Office inventory requirements.

3. Only authorized individuals in Environment, Health, and Safety (EHS) may package and ship radioactive material from NCI-Frederick.

L. Radioactive Waste

1. Radioactive waste is described as any waste or discarded material that contains or is contaminated with radioactivity. Examples: dry waste such as contaminated gloves and paper towels; stock vials; reagents (low-volume, high-activity nonhazardous liquids); carboys (usually 5-gallon containers with relatively low activities and nonhazardous liquids); contaminated equipment, etc.

2. To schedule a waste pickup, please e-mail radwaste@mail.ncifcrf.gov or call **X1384** and leave your name, telephone extension, building and room number, program number, and type of waste, including isotope and activity. Please contact the Waste Management Department no later than 8:00 a.m. on the day of the scheduled pickup to be included for that week's pick up. Dry radioactive waste, stocks, reagents, and scintillation vials are picked up on Tuesdays. Carboys are picked up on Thursdays.

3. Never place radioactive waste in the corridors, even while awaiting pickup. All radioactive waste must remain secure unless under constant surveillance.

M. Disposal of Radioactive Material

1. The majority of radioactive waste generated at NCI-Frederick falls into one of the following categories: solid radioactive dry waste (includes sharps); radioactive biologicals; stocks; radioactive liquids; and scintillation vials (including survey vials, which are background).

2. **Solid radioactive dry waste**: All solid radioactive waste, including sharps, must be segregated and packaged based upon the following isotopic half-lives:

   a. Class 1: Isotopes with a half-life of less than 15 days (32P)
   Class 2: Isotopes with a half-life of 15 to 100 days (33P, 51CR, 35S, 125I,111In)
   Class 3: Isotopes with a half-life greater than 100 days (3H, 14C)

   b. All sharps must be stored in a sharps container or a sturdy cardboard box to prevent any exposures or sticks. Please keep sharps separate from other dry wastes. Follow all other dry radioactive waste labeling requirements.

   c. Each class of waste must be placed into separate, properly labeled and sealed, clear plastic bags. Each properly labeled and sealed plastic bag may contain only "solid waste," which means no scintillation vials, no liquid, no stock containers, and no sharps. Any "solid waste" that does not meet the above-mentioned criteria will be returned to the generator.

d. Each sealed bag must be individually labeled with the following information: program number, user name, isotope, and activity. The Drum/Container Log (Radioactive Dry Waste Log Sheet) must also be completed. If the log has not been signed and dated certifying it for pickup, the container will not be removed.

e. Solid radioactive waste shall not be placed in liquid waste containers.

3. **Radioactive biologicals**: All radioactive biologicals, including items such as bodies, excrement, organs, contaminated bedding, and tissue samples containing radioactivity, should be segregated according to the following isotopic half-lives:

    a. Class 1: Isotopes with a half-life of less than 15 days (32P) Class 2: Isotopes with a half-life of 15 to 100 days (33P, 51CR, 35S, 125I, 111In) Class 3: Isotopes with a half-life greater than 100 days (3H, 14C)

    b. Each class of radioactive biological waste must be placed into separate, properly labeled and sealed, clear plastic bags. If the waste is frozen, keep it frozen and the Waste Management Department will pick it up in that condition. Please contact the Radiation Waste Department if your waste is difficult to package or seal, and they will assist you with packaging.

    c. Each sealed bag must be individually labeled with the following information: program number, user name, isotope, and activity. If there are multiple bags inside a storage container or box, please use a Drum/Container Log (Radioactive Dry Waste Log Sheet) to track each sealed bag, following the same procedure that is used for radioactive dry waste.

    d. Biologicals do not include items such as paper, needles, blood-soiled lab coats, etc.

4. **Stocks**: All stocks are picked up on Tuesday with the radioactive dry waste. Please keep all stocks separate from the other items for pick up.

    a. If there are multiple stocks, please consolidate them by isotope in a clear, sealed bag.

    b. Each stock or sealed bag must be individually labeled with the following information: program number, user name, isotope, and activity.

5. **Radioactive liquids**: Carboys are used to collect the bulk aqueous radioactive liquid. This generally consists of buffers, salts, and water. No hazardous

compounds should be placed into these containers. The pH of each carboy should be between 5 and 9, and the carboy must not exhibit any characteristic hazards such as flammability, toxicity, or corrosivitity.

a. The Waste Management Office recommends that each carboy remain isotopic specific, but in certain situations isotopes may be mixed within the storage container. The following activity limits apply to the 5-gallon carboy containers.

14C	2 millicuries
3H	3 millicuries
35S	4 millicuries
125I	1 millicurie
51Cr	1 millicurie
33P	1 millicurie
32P	1 millicurie
111In	1 millicurie

b. Reagents are generally low-volume, high-activity solutions that do not meet the activity requirements for bulk radioactive liquid waste. No hazardous compounds should be placed into these containers. The pH of each reagent should be between 5 and 9, and the reagent must not exhibit any characteristic hazards such as flammability, toxicity, or corrosivitity. Please contact the Waste Management Department at **X1384**, before generating any reagents.

c. All radioactive liquid waste must be stored and transported in sealed containers. Preferably, all containers used to store radioactive liquids should have some form of secondary containment. The only time that a container should be opened is when adding waste to it.

d. Each time an entry is made to the storage container, the Radioactive Waste Log (Liquid Radioactive Waste Disposal Sheet) must be filled out and signed. The Radioactive Waste Log contains the following information: program number, user name, isotope, and activity. The Radioactive Waste Log may be used for both carboys and reagents.

e. The Liquid Decay Storage Facility (LDSF) is a pilot program designed to reduce disposal costs and limit the liability associated with the disposal of liquid low-level radioactive waste. The LDSF focuses specifically on the storage and decay of 32P. Isotope-specific carboys, funnels, and equipment are provided to participating radiological programs. If you have any questions, please call **X1384** for more information.

f. Do not place liquid radioactive waste into dry waste containers.

6. **Scintillation vials**: The Waste Management Department will pick up all scintillation vials, whether or not they contain any radioactivity. If radioactivity is used, please try to use a nonhazardous scintillation cocktail to avoid generating mixed waste. The warehouse stocks nonhazardous scintillation fluids, and if one of these does not suit your needs, please contact the Radiation Waste Department for assistance.

    a. Return used vials to the compartmentalized cardboard containers or double-bag the vials after separating them into the following categories:

        i. Scintillation vials containing 3H and 14C with an average of less than or equal to 0.05 microcurie per gram or 3 x 104 cpm/mL for each vial may be grouped together for disposal purposes. Scintillation vials that do not meet this activity requirement should be grouped separately.

        ii. All other vials containing isotopes with half-lives of less than 100 days, such as 32P, 35S, 33P, etc., should be segregated by isotope and stored together. The Waste Management Department suggests that scintillation vials with half-lives of less than 100 days be stored for decay in the laboratory.

        iii. Please keep together all scintillation vials that are "background" or radiation free, such as survey swipes.

    b. All scintillation vials except for background vials must be clearly labeled as radioactive waste and contain the following information: program number, user name, isotope, and activity. Each individual container or bag must be labeled.

    c. An NCI-Frederick Hazardous Waste Tag should accompany the scintillation vials, including background vials, identifying the scintillation fluid and amount that is contained within the vials.

7. For more radiation waste disposal information, click on the following address: http://home.ncifcrf.gov/ehs/ehs.asp?id=92

N. Labeling and Signage

1. All areas where radioactive materials are used or stored shall be conspicuously posted with a standard "Caution – Radioactive Materials" sign.

2. In all areas where radioactive materials are used, Radiation Safety will post Form NRC-3, "Notice to Employees," and a notice indicating the location for inspection of the following:

    a. NRC regulations

    b. NRC license

    c. All correspondence relating to the license

3. Radiation caution signs or labels will be attached to all fume hoods, containers, and other equipment that contain or are contaminated with radioactive materials. These signs will have the following information printed on them:

    a. The radiation caution symbol

    b. The words "Caution-Radioactive Materials"

4. Hot rooms are used exclusively for work involving radioactive materials and will be posted with an additional hot room designation sign.

5. At the discretion of the RSO, additional items such as barricades, ropes, and painted warning lines may be required.

V. Decontamination

A. Equipment Decontamination

1. The RSO/RSS should be contacted for assistance in all radiation decontamination procedures.

2. The easiest way to solve the problem of equipment contamination is to use procedures that prevent the contamination initially. Sometimes equipment can be protected with plastic or other types of containment that will prevent contamination.

3. If biological materials are involved, the biological decontamination or sterilization must be performed before radiation decontamination. Biological treatment consists of placing the equipment in nonporous containers and then either autoclaving, treating with ethylene oxide, or utilizing methods approved by the Biological Safety Office.

4. The maximum permissible contamination levels for alpha and beta-gamma radiation are 10 and 500 disintegrations per minute, respectively, for an area

of 100 cm^2. These limits are for removable contamination. The definitions for removable and nonremovable contamination are listed below:

a. **Removable contamination:** Any contamination that may be removed with routine cleaning using such cleaning agents as Count-Off™ or soap and water, and paper towels. Removable contamination should leave no trace behind, and equipment should be below the limits listed above or at background radiation levels after cleaning.

b. **Nonremovable contamination**: Any contamination detected above background limits listed above after proper cleaning. Nonremovable contaminated equipment requires labeling with radioactive tape stating the isotope, dpm, and date of contamination.

5. The individual responsible for the contamination will be expected to do most of the cleanup under the supervision of the RSO/RSS.

B. Personnel Decontamination

1. The most important aspect of personnel decontamination is speed. First, all contaminated clothing must be removed and the body monitored to locate contaminated areas. If the contaminated area is small, then the decontamination can be performed in the laboratory. If large areas are contaminated, then the person involved should be dressed in expendable clothing and taken to the showers.

2. Affected areas must be washed with soap and water. Use of a brush or abrasives is not advised. Affected areas should be dried and monitored again for contamination. This procedure should be repeated no more than four times. If contamination persists, the physician at OHS, **X1096**, should be contacted.

3. Prolonged use of any one method of decontamination should be avoided because skin irritation might result, which could lead to the absorption of radioactive material into the body through breaks in the skin. Organic solvents should not be used.

4. If laboratory clothing becomes contaminated, it should be placed in a plastic bag. The RSO/RSS should be notified and the clothing biologically decontaminated if necessary.

5. The RSO/RSS must be notified of any personnel contamination.

VI. Accidents Involving Radiation

A. Radioactive Material Spill

1. The following general procedures shall be followed when a radioactive material is spilled.

    a. Provide necessary emergency first aid to all serious injuries.

    b. Evacuate all personnel to an area removed from the effects of the spill, and close all entrances to the spill area.

    c. If airborne radioactive materials are suspected, close all doors. Turn off hoods and safety cabinets that do not exhaust to the outside.

    d. Immediately call the RSO/RSS on extension **X1451**. After hours, call Protective Services at extension **X1091**.

    e. Keep all persons known or suspected of being contaminated confined to one area to prevent the further spread of contamination. Do not allow other persons to enter this area.

2. The RSO/RSS will immediately dispatch personnel and necessary equipment to the scene of the incident and shall perform the following upon arrival at the scene:

    a. Ascertain that all personnel have been evacuated from the hazard area, ensure that entry into the area has been restricted, and ensure that all serious injuries have received medical attention.

    b. Monitor all personnel involved in the incident to determine the extent of the contamination. The RSO/RSS will initiate necessary personnel decontamination procedures. The PI or other authorized radiation worker may start monitoring prior to the arrival of the RSO/RSS.

    c. Evaluate the hazard area.

    d. Supervise the decontamination and return the laboratory to normal operating conditions.

    e. Investigate the cause of the incident and report to the RSC on the cause as well as actions taken to prevent such an incident in the future.

B. Fires or Explosions Involving Radioisotopes

    1. When a fire or explosion involving radioisotopes occurs, the RSO/RSS will be notified immediately, and the Proper Damage Control Office will be called.

2. The RSO/RSS will monitor all damage control equipment and personnel for contamination before permitting these items/people to leave the area. The only exception to this policy is in the event that personnel are seriously injured. In this case, the medical personnel involved will be informed that the person is or might be contaminated.

3. All damage control personnel will be equipped with dosimeters and respiratory protective devices when entering such an area. This policy shall not prevent entry in order to perform a life-saving rescue.

4. The Fort Detrick Fire Department will:

    a. Maintain familiarity with the location of all radiation areas, and notify the RSO/RSS whenever a fire involves radioisotopes.

    b. Wear dosimetric and respiratory equipment when responding to an incident where radioactive materials are used.

5. Protective Services personnel will notify the RSO/RSS of any radiation accident during off-duty hours.

6. OHS will:

    a. Observe the precautions and procedures prescribed by the physician in handling patients who are or may be contaminated with radioactive materials.

    b. Wear the necessary dosimetric and protective equipment as instructed by the RSO/RSS and the physician.