Advanced Technology Research Facility (ATRF)

Radiation Safety Manual

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RADIATION SAFETY MANUAL
AVANCED TECHNOLOGY RESEARCH FACILITY

FOREWORD

The use of radioactive materials and devices that produce ionizing radiation is necessary to conduct research at the Advanced Technology Research Facility. This manual presents general guidance on the necessary precautions and regulations 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 Maryland Department of the Environment (MDE). The contents of this manual are an integral part of that license and, as such, are enforceable by the State.

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. This manual sets forth the responsibilities of the Committee and of the Radiation Safety Office. It also details the responsibilities of persons who handle radiation sources and identifies the necessary requirements for the safe use of such materials.

All individuals 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. It is the responsibility of a radiation worker to seek out specific training and instruction for procedures in his or her laboratory from the supervisor, other trained workers, or the Radiation Safety Office.

Signature on file 10-19-12
JT Moore Date
Radiation Safety Officer, SAIC-Frederick, Inc.

Signature on file 10-22-12
Dwight Nissley, PhD. Date
Radiation Safety Committee Chair, SAIC-Frederick, Inc.

Signature on file 10-25-12
David Heimbrook, PhD. Date
Chief Executive Officer, SAIC-Frederick, Inc.

Signature on file 10-29-12
Craig Reynolds, PhD. Date
Associate Director, Frederick National Lab for Cancer Research

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Advanced Technology Research Facility (ATRF)

RADIATION SAFETY MANUAL

I. Administrative Controls

A. Radiation Safety Committee

1. General

The ATRF Radiation Safety Committee (RSC) was established by the Chief Executive Officer (CEO), Frederick Operations, Science Applications International Corporation (SAIC-Frederick, Inc.), to ensure that all sources of ionizing radiation at the ATRF are used safely and in a manner that complies with all applicable regulations. All rules and policies pertaining to the license and its administration at the ATRF are established by the RSC. The RSC reports to the CEO, 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 the ATRF.

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

c. Assure that users of radiation sources are meeting applicable regulations and ATRF 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 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 Maryland Department of the Environment (MDE) regulations or ATRF 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.

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3. Committee Membership

   a. The ATRF RSC is comprised of representatives from all operating groups within active radiation programs. These representatives are appointed by the CEO, 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 responsible for the oversight of all day-to-day handling of radioactive materials and other sources of ionizing radiation at the ATRF. 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 the ATRF are in compliance with all applicable regulations.

   b. The RSO performs and supervises a surveillance program to ensure that all operations at the ATRF involving ionizing radiation are in compliance with applicable regulations and ATRF 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 the ATRF.

   e. The RSO/RSS ensures that all shipments of radioactive materials being delivered to the ATRF are received and inspected in accordance with MDE Regulations and license requirements.

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

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

3. Authority

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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 may be contaminated.

b. The RSO may suspend, pending RSC review, any project or procedure that is in violation of MDE regulations or ATRF 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 Radiation Program Principal Investigator (PI) is a person who is directly responsible for a specific project under an approved radiation program issued in writing by the ATRF 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 ATRF policies, procedures, and regulations are 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 any 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 ATRF 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.

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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, radiation producing machines, electron microscopes, etc.) the written approval of the ATRF 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 the ATRF must be performed under an approved radiation program. The proposed Radiation Program PI shall submit for approval a Radiation Program Application to the ATRF RSC, through the ATRF RSO. The application contains:

1. Program Design

The following should be considered when applying for a new radiation program:

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

b. 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 easy to clean.

c. 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.

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

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

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

g. 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.

2. **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/RSS 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 proposed PI and RAS. 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.

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

c. The location (room number) for waste storage, both dry and liquid.

d. A list of the protocols, associated radioisotope(s) and the maximum amount of activity (in mCi) to be used during each experiment, as well as the maximum amount of activity (inventory) of each isotope to be maintained under the program. If other sources of ionizing radiation are to be used (Irradiators, X-ray machines, electron microscopes, etc.), specific information concerning these sources must be included on the appropriate application form.

e. A complete list of the radiation monitoring equipment, i.e. liquid scintillation counters, Geiger counters, gamma counters, etc. available for the proposed program in authorized use areas.

f. A list of all individuals to be placed on the proposed program.

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

3. **Training and Experience Forms (T&E Forms)/User Application Forms:** T&E and User Application Forms for the various types of radiation programs can be accessed at the following address:

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

a. Radioisotope Programs

The proposed PI and radiation workers must have appropriate training and experience in the use of the proposed radioactive materials. The RSC will evaluate their training and experience relative to the isotopes and possession limits requested in the application for a radiation program. New **Radioisotope Training and Experience Forms** for all personnel (including the proposed PI) must be provided in the application packet.

The proposed PI must sign all of the 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.

b. Irradiator Programs

The proposed PI and radiation workers must complete an **Irradiator Users Application Form**. The proposed PI must sign all of the forms and include them with the program application.

c. X-ray Programs

The proposed PI and radiation workers must complete an **X-Ray Program Users Application Form**. The proposed PI must sign all of the forms and include them with the program application.

d. Electron Microscope Programs

The proposed PI and radiation workers must complete an **Electron Microscope Users Application Form**. The proposed PI must sign all of the forms and include them with the program application.

4. **Radiation Safety and Equipment Specific Training:**

a. Radioisotope Programs

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All proposed radiation workers (including the proposed PI) for radioisotope programs must complete the ATRF Radiation Safety Training for New Users.

b. Irradiator Programs

All proposed radiation workers (including the proposed PI) for irradiator programs must complete the ATRF Radiation Safety Training for New Users as well as equipment specific training.

c. X-ray and Electron Microscope (EM) Programs

All proposed radiation workers (including the proposed PI) for X-ray and EM programs must complete equipment-specific training.

For more information see section III: B Training.

5. Include copies of all radioisotope protocols associated with the proposed radiation program.

6. Include copies of the "Operations and Emergency Procedures" for Irradiator, X-ray and EM proposed programs.

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

8. The application and all associated paperwork are submitted to the RSO. After review, the RSO will forward the application to the RSC for approval.

9. Prior to forwarding the application to the RSC, the RSO will review the Radiation Program Application to ensure 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.

10. 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 PI and radiation workers.

11. An ATRF *radiation program number* will be assigned to the program upon approval of the application. **Radiation operations shall not begin until the proposed PI has received a confirmatory memo indicating that the program has been approved by the RSC.**

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12. Any future change in the parameters of the radiation program must be approved in writing prior to initiation. These include such things as changes in isotopes, activity levels, and radiation workers.

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 remain compliant with ATRF policy and MDE regulations.

1. Programs cannot share isotopes without prior approval from Radiation Safety. Even small aliquots must receive prior approval. Only authorized isotopes may be transferred to another program.

2. 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 vice versa.

C. Amendments to the Radiation Program

1. Any request for an 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. **Only the PI can add new radiation workers to the program.**

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

   a. Radiation workers are added or removed.

   b. Changes occur in radioisotopes.

   c. Activity usage level change.

   d. Rooms are added or removed from the radiation program.

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

D. Program Renewals

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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 reviewed by the program PI for accuracy.

3. Each person listed on the renewal application must complete and sign the abbreviated Radiation Training and Experience Form, which will be included in the Radiation Program Renewal Application, with any new information.

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.

5. Copies of current protocols must also be included with the renewal application.

6. 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.

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

8. 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 sent back to the PI/RAS, indicating that the requested changes have been made to the Program.

E. 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 distributed by the Radiation Safety Office in January and July of each year.

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

d. Any transfer of radioactive material to another radiation program at the FNLCR must be recorded on the RMAR and authorized by the RSO/RSS in advance. For more information see section V: L. Inter-Program Transfers/Shipment of RAM

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

2. 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 level is 220 disintegrations per minute (dpm) for an area of $100cm^2$. These limits are for removable contamination. For more information see section V: 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.

3. 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.

c. The PSTD is a living document. The PI is responsible to keep it updated with current protocols.

F. Dormant Programs

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1. Approved ATRF Radiation Safety Programs may go into dormancy as long as no RAM of any kind is possessed, and monthly non-use certificates are completed and documented.

    a. A Radiation Safety Program must provide the ATRF Radiation Safety Office with a written request for dormancy. The required form is located at Request for Consideration as a Dormant Radiation Program

    b. Once a request for dormancy is received, the RSO/RSS will perform an inspection of all authorized RAM-use areas to ensure that the Program has met the necessary criteria for dormancy.

    c. The RSO/RSS will provide the PI/RAS with written confirmation that dormancy has been achieved; only then is the Program considered to be in dormant status.

2. A Dormant Program may not possess any RAM, nor perform any RAM manipulations while in dormancy.

3. A Dormant Program must provide the Radiation Safety Office with copies of monthly non-use certificates and retain copies on file, within the Program, for review by auditors and regulators. The required non-use certificate is located at Monthly Non-use Certificate

4. Typical Program requirements (such as training, program renewals and audits) must still be performed. Monthly non-use certificates will replace monthly contamination surveys in laboratory records.

5. Radiation Safety will continue to perform monthly contamination surveys.

6. Survey meters must be maintained in usable, calibrated condition.

7. The discovery of unauthorized use of RAM in a Dormant Program may result in closure of the Program.

8. Programs may be reactivated by completing a written request to end dormancy. The required form is located at Request to Return to Active Radiation Program Status. The program is not active until the PI/RAS has received written confirmation from the RSO that the program has been reactivated.

G. Termination of a Radiation Program

Whenever a radiation program is to be terminated or an area returned to non-radiation use, the PI/RAS must submit the request to the RSO in writing.

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1. Upon receipt of the request to terminate, the RSO/RSS will confirm the following:

   a. All sources and contamination have been removed.

   b. All radioactive waste containers have been removed.

   c. All warning signs have been removed.

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

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

2. Once the above items have been confirmed, the PI/RAS will receive a written statement from the RSO, stating 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 MDE regulations, ATRF 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 CEO, 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

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Permission to use radioactive materials and/or sources of ionizing radiation at ATRF is contingent upon the completion of all required radiation safety training courses. Approval to use radioactive material must be granted by the RSO prior to use.

1. Radioisotope and Irradiator Workers

   a. Proposed radioisotope and irradiator workers must successfully complete the ATRF Radiation Safety Training for New Users computer-based training (CBT) course before they can become authorized users. This course covers aspects of radiation operations, regulations, and policies required at the ATRF, as well as radiation physics, and general safety.

      A MyNCI-F username and password are required to access this training. Go to http://my.ncifcrf.gov/ for assistance with your username and/or password.

   b. Proposed radioisotope workers must also complete protocol-specific training. 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 radioisotope workers, regardless of prior experience and background, must thoroughly review this document with their PI or RAS and confirm their understanding of the material by signing the signature sheet attached to the PSTD.

   c. Proposed irradiator workers must complete the indoctrination session which delineates the operational procedures for the unit as well as the administrative protocols presently in effect governing its use.

   d. Approved radioisotope and irradiator workers must also complete the ATRF Annual Radiation Safety Refresher Training every year. The RSS will send a memo with training login number and radiation program number to radiation workers when training is due.

2. X-ray and Electron Microscope Workers

   Proposed x-ray and electron microscope workers must complete the indoctrination session which delineates the operational procedures for the unit as well as the administrative protocols presently in effect governing its use.

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.

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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 request in writing 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 MDE regulations, ATRF 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 V: A. ALARA / Time, Distance and 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 promptly made to the PI and 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 and 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 ATRF termination process to turn in any dosimetry badges and provide final bioassay samples or sign a declination statement.

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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 on the Radioactive Material Accounting Records (RMAR).

8. Ensure that the laboratory is surveyed for radioactive contamination frequently, and ensure that a formal monthly contamination survey is performed and documented within all authorized use areas. For more information see section V: 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 in any sink or drain at the ATRF. ANY RADIATION ABOVE BACKGROUND LEVELS FOUND IN SINKS AT THE FNLCR IS IN DIRECT VIOLATION OF MDE LICENSE CONDITIONS. For more information see section V: P. Radioactive Material Sink Policy.

13. Perform work with volatile radioisotopes or with other radioactive materials that may become airborne in a hood approved for low-level radioactive materials.

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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 under constant surveillance must be secured from unauthorized removal or access at all times.**

IV. Basic Health Physics

A. 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-99m 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
$\mathbf{A_0}$ = 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 $\mathbf{A_0}$ 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.

B. Radiation Units

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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. ATRF laboratories routinely use only millicurie (mCi) or microcurie (µCi) amounts of radioactive materials.

2. Units of Exposure

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

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

   b. 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. *Airborne radioactivity area* means a room, enclosure or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations-

      i. In excess of the derived air concentrations (DACs) specified in Appendix B, Table I of Part D of COMAR 26.12.01.01, or

      ii. To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

   b. *High radiation area* means an area, accessible to individuals, in which radiation levels from radiation sources external to the body 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 30 centimeters from any surface that the radiation penetrates.

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

d. *Restricted area* means an area to which access is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

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:

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

ii. 3.75 rems to lens of the eye

iii. 12.5 rems to the extremities

iv. 12.5 rems to the skin of the whole body.

e. *Unrestricted area* means an area, access to which is neither limited nor controlled by the licensee.

In an *unrestricted area* in which members of the general public (non-radiation workers) can or may be found, the maximum permissible dose rate is 0.002 rem (0.02 millisievert) per hour and may not exceed 0.1 rem (1 millisievert) in a year. All reasonable efforts should be made to keep exposure rates in unrestricted areas below this limit.

C. Biological Effects of Radiation

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.

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

1. *External exposure* occurs 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.

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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.

2. *Internal exposure* occurs when radiation is emitted from radioactive materials present within the body and can occur from all forms of radiation. Internal exposures may occur through any of four routes of entry:

a. Inhalation of airborne radioactive material can result in absorption by the lungs and deposition in the body.

b. Ingestion of radioactive contaminated food, drink, or other consumable products.

c. Injection of radioactive material from a needle stick.

d. Radioactive material is spilled or aerosolizes onto the skin and is absorbed or enters through breaks in the skin; or via contaminated hands, after subsequent eating or rubbing of eyes.

V. ATRF License Conditions and Procedures

A. ALARA / Time, Distance and Shielding

The ATRF 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. The ATRF'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:

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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 particles 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 lists maximum particle range for some common isotopes used at the ATRF:

Isotope	Maximum Energy in Mev	Maximum Range
H-3	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, C-14, and S-35): Shielding is not normally required because their emissions are too weak to penetrate clothing or the surface layer of the skin.

ii. For high-energy beta emitters (P-32): P-32 is most effectively shielded with 3/8-inch thick Plexiglas shields. Lead should not 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

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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 any area in which radioactive materials are authorized to be used or stored.

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 use area.

B. Internal Exposure - Bioassays

1. Urine Bioassays

a. A baseline urine bioassay will be performed for all proposed radioisotope workers. RSS will contact the proposed radioisotope worker to submit the baseline urine bioassay sample after all required paperwork has been received and training completed.

b. Urine bioassays may also be performed after spills, contaminations or other abnormal occurrences as determined by the RSO/RSS.

2. Thyroid Scans

a. Radiation workers requesting authorization to use radioactive iodine (bound or unbound) must receive a baseline thyroid scan prior to manipulating radioactive iodine. The RSO/RSS will contact the individual to schedule their baseline scan(s) after all required paperwork has been received and training completed.

b. Radiation workers performing iodinations must receive a thyroid scan in accordance with Part D below.

C. External Exposure - Dosimetry

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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 radiation exposure. The RSO, with the approval of the RSC, may permit exceptions or may initiate additional requirements to this policy.

2. The following radiation workers will be issued a thermoluminescent dosimeter (TLD) ring badge.

    a. Authorized to manipulate 10 mCi or more of P-32.

    b. Perform iodinations

    c. Members of the Small Animal Imaging Program, SAIP.

    d. Members of the Radiochemistry / Radiopharmacy programs, SCIP.

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, monthly or weekly basis.

    a. Quarterly change frequency – All dosimetry badges except those listed in b and c below.

    b. Monthly change frequency – Fetal monitoring badges, SAIP and special room monitors.

    c. Weekly change frequency – SCIP

5. 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. It is asked that the location of dosimetry devices be consistent to assist RSS in locating the devices, and to reduce unreturned devices.

6. A Radiation Dosimetry Report from our dosimeter provider will be sent to the radiation program's PI or RAS each quarter, month or week, respectively. All badged radiation workers have access to their personnel exposure information listed on these reports. The results from a dosimetry report become 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

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exposures (in rem) and personal information used to identify each worker and will be available from the Radiation Safety Office by personal request. For general information regarding these reports please click on the following link:

Annual Dosimetry Report General Information

8. RSS will notify the radiation worker when an exposure above 130 mrem, for quarterly and monthly badges, and 500 mrem, for weekly badges, 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 the FNLCR radiation exposure monitoring results for the past 40 years indicates that occupational radiation exposures nearing regulatory limits are not likely. In fact, most occupational radiation exposures received by radiation workers at the FNLCR are below the minimum detection capabilities of the exposure monitoring devices currently in use.

D. Iodinations

1. Iodinations must be performed in an approved chemical fume hood or an approved biological safety cabinet equipped with the appropriate charcoal filter and exhausting systems. 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.

2. Radiation workers who are approved to work with free or unbound iodine and wish to perform an iodination must notify Radiation Safety **prior to** performing the experiment to schedule pick up of:

   a. Isotope - All free / unbound iodine is held in Radiation Safety and must be signed out, with any unused isotope returned.

   b. Iodination Schedule Form – is used to record pertinent information about the iodination and as a reminder to the individual performing the iodination of their thyroid scan appointment.

      i. The sampling time interval

      ii. The iodine isotope used in the experiment

      iii. The date of the procedure

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

      v. The date and time of the scheduled thyroid scan.

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c. A Breathing Zone Tube is used to monitor the air for iodine in the breathing zone just outside of the iodination hood.

3. The bottom half of the Iodination Schedule Form, the breathing zone tube, and any unused isotope must be returned to Radiation Safety as soon as possible after completing the iodination.

4. 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).

E. Declared Pregnant Workers

1. 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).

2. 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.

a. NRC Regulatory Guide 8.13

b. Declaration of Pregnancy Form

c. Form to withdraw declaration

3. If the radiation worker chooses to declare her pregnancy (she may choose not to), a fetal monitoring badge (if applicable) will be provided.

4. 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.

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

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

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 at all times. This applies to refrigerators/freezers, cabinets, or lock boxes containing stock isotopes, as well as 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. Unattended laboratory rooms containing unsecured radioactive material or other sources of ionizing radiation must be locked, even during working hours.

4. Corridors are not secured areas. 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. All 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.

2. Authorized radioisotope programs must perform and document a contamination swipe survey **at least once a month** in all authorized use areas of the program

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regardless of the quantities of radioactive material utilized within the month. Some programs, such as SAIP and the Radiochemistry / Radiopharmacy programs, must be surveyed on a weekly basis.

3. A Geiger counter, with the appropriate calibrated detector, may aid in performing the survey for high-energy beta and gamma emitters such as P-32, Cr-51, In-111, etc.

4. Surveys are performed by wiping a surface area of 100cm^2 with filter paper, or other approved swiping material, and then determining the activity with a liquid scintillation counter (LSC) or gamma counter (GC) as appropriate. A positive (sealed source H-3 and/or C-14 standards for the LSC or Cs-137 or other gamma emitter for the GC) and negative (background standard) control shall be run along with the swipes. The positive and negative controls must be included on the LSC and/or GC survey printout each month.

5. The decontamination action level for the ATRF is 220 dpm/100 cm^2 removable contamination. Radioactive contamination must be cleaned to ALARA levels.

   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 should be below the limits listed above or at background radiation levels after cleaning.

   b. **Non-removable contamination**: Any contamination detected above limits listed above after proper cleaning. Non-removable contamination must be properly labeled with the following and properly shielded.

      i. The trefoil symbol and the words "Caution Radioactive Material". Radiation tape can be used to meet this requirement.

      ii. The isotope

      iii. The activity in dpm

      iv. The date of contamination.

6. All positive contaminations must be properly cleaned, re-swiped, and read on the LSC / GC with a printout attached to the original results. The positive and negative controls must be run with all re-swipes.

7. All documented surveys must include:

   a. A properly completed standard "Contamination Survey Results" sheet or equivalent.

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b. A diagram or map indicating the locations of the swipe/survey points. The diagram/map shall show the locations of benches, desks, sinks, hoods, etc. within all authorized use areas belonging to the program.

i. 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.

ii. Areas tested should be representative of areas where contamination might be expected as well as some areas where contamination would not be expected.

c. The original LSC / GC results and any rerun/re-swipe results with the positive and negative controls indicated on the printouts.

8. Each properly documented monthly contamination survey must be kept on file in the laboratory for review by RSO/RSS. It is recommended that all authorized radiation workers know the location of this file.

9. A post-experimental contamination survey must be performed whenever radioactive materials are used. Special attention should be given to equipment used with radioactive materials i.e. centrifuges, incubators, water baths, etc.

10. A survey shall also be performed whenever there is reason to suspect contamination.

11. The individual responsible for the contamination will be expected to do most of the cleanup.

12. The RSO/RSS should be contacted for any questions on radiation decontamination procedures.

H. Radiation Safety Surveys

1. Radiation surveys performed by 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 when 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 program staff must also perform 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 the ATRF on at least a monthly basis.

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3. Maximum permissible removable contamination level is 220dpm/100cm^2. Any swipe results meeting or exceeding these levels will be re-read to check for accuracy by RSS. The RSS will attempt to notify the PI/RAS of any contaminations by phone as soon as possible. All contaminations will be documented in the Survey Report that is sent to the PI/RAS.

4. All contaminations found by the RSO/RSS must be addressed by the program PI/RAS.

   a. The radiation program personnel must clean and re-swipe all reported areas of contamination.

   b. The PI/RAS is responsible to properly complete the Contamination Clean-up Sheet, attached to the Monthly Survey Report, with the post clean-up dpm results.

   c. The Contamination Clean-up Sheet and a copy of the post clean-up swipe results must be returned to the RSO/RSS within 3 business days of receipt.

5. Radiation Safety will also check the following areas for compliance:

   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

6. Any deficiencies (deviations from compliance with the above) will be noted in the Monthly Survey Report and on a Deficiency Memo. The PI/RAS must respond in writing, indicating corrective actions, to the RSO/RSS within 5 business days of receipt.

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

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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 accurately recorded.

I. Procurement of Radiation Producing Machines

Radiation Producing Machines - 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.

The procurement of radiation producing machines requires prior approval of Radiation Safety. This equipment may only be possessed by an approved radiation program authorized for the use of the specific instrument.

J. Procurement of Radioisotopes

The procurement of radioisotopes or byproduct material regulated by the MDE and/or requiring a radioactive material use license issued by the MDE must be preapproved by Radiation Safety.

1. Authorized radiation workers can only order materials with which they are authorized to work.

2. Only authorized personnel (usually administrative) are able to order radioisotopes for a program. **Please be sure to let Purchasing personnel know that the order is for radioactive material.**

3. 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 in millicuries (mCi) or microcuries (uCi)

   e. The catalog number

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f. The name of the company (Perkin Elmer, MP Biomedicals, etc.)

g. The ATRF radiation program number (84-05, 86-09, etc)

4. RSS will approve (or disapprove) all radioactive material orders on-line. If pertinent information is missing from the request, RSS will attempt to contact the requester for clarification. If the requestor cannot be contacted, the order may be rejected by RSS. To avoid delays, please be sure all information is complete and accurate.

5. The RSO will ensure that licensed radioactive material is received, inventoried and delivered to the end user in compliance with MDE regulations, license conditions and ATRF policies and procedures

K. Radioisotope Inventory

1. Upon receipt of radioactive material, the RSS will ensure radioisotopes are processed and inventoried in accordance with MDE regulations, license conditions and ATRF policies and procedures.

2. Every effort will be made by RSS to deliver the material to the requester within four hours of receipt 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 (RMAR), also referred to as yellow sheets. The RMAR represents the program's record of active inventory.

4. The RMAR 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 radioisotope must have an associated RMAR. 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

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section V: M Disposal of Radioactive Material for details regarding disposal). Return the completed "yellow sheets" 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 MDE.

8. RSS will perform inventory checks every six months. The six-month inventory is usually performed each January and July. RSS will send 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 radioisotope programs. The questionnaire and program review are to be completed, signed by the PI or RAS and returned within two weeks of receipt. 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 radioisotope 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.

L. 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 the ATRF **must be approved in advance** through the Radiation Safety Office. This is done to ensure conformance with MDE, U.S. Department of Transportation, and other shipping regulations as well as with the Radiation Safety Office inventory requirements.

3. The RSO will ensure that all radioactive material shipments from the ATRF are in compliance with MDE and DOT regulations.

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M. Disposal of Radioactive Waste

Radioactive waste is described as any waste or discarded material that contains or is contaminated with radioactivity. It is divided into 6 major categories. If you need assistance, call EHS Waste Management Staff (WMS) at x1384.

1. **Solid Radioactive Dry Waste** – consists of contaminated gloves, paper towels, bench paper, sharps (needles, syringes, pipette tips, glass, etc.), etc.

   a. All solid radioactive dry waste (including sharps) must be segregated based on the following half-life categories.

      i. Class 1: Isotopes with a half-life of less than 15 days (P-32, F-18, Tc-99m)

      ii. Class 2: Isotopes with a half-life of 15 to 100 days (P-33, Cr-51, I-125, S-35)

      iii. Class 3: Isotopes with a half-life greater than 100 days (H-3, C-14) plus In-111 and Zr-89 (due to long half-life contaminants and daughter products).

   b. Each class of solid dry radioactive waste (except for sharps) 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, liquid, stock containers, or sharps. Any solid waste that does not meet the above-mentioned criteria will be returned to the generator.

   c. All sharps must be stored in a sharps container to prevent any exposures or sticks. Please keep sharps separate from other dry wastes and do not place them into the solid radioactive dry waste containers. Follow all other dry radioactive waste labeling requirements.

   d. Each sealed bag (and sharps container) must be individually labeled with the following information

      i. Radiation program number

      ii. User name

      iii. Isotope

      iv. Activity

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v. Date

e. Each properly labeled and sealed bag of solid radioactive dry waste shall be placed into the solid radioactive dry waste container and the drum/container Log (Radioactive Dry Waste Log Sheet) must be completed with a separate line entry for each bag.

f. **DO NOT** place liquid waste into solid radioactive dry waste containers.

g. Once the solid radioactive dry waste container is full; sign and date the waste log sheet, certifying it for pickup, and contact WMS, x1384, for collection. WMS will not collect containers with incomplete log sheets.

2. **Radioactive Biologicals** - include animal bodies, excrement, organs, contaminated bedding, tissue samples, etc. containing radioactivity. Biologicals do not include items such as paper, needles, blood-soiled lab coats, etc.

a. All radioactive biological material should be segregated according to the following isotopic half-lives.

i. Class 1: Isotopes with a half-life of less than 15 days (P-32, F-18, Tc-99m)

ii. Class 2: Isotopes with a half-life of 15 to 100 days (P-33, Cr-51, I-125, S-35)

iii. Class 3: Isotopes with a half-life greater than 100 days (H-3, C-14) plus In-111 and Zr-89 (due to long half-life contaminants and daughter products).

b. Each class of radioactive biological waste must be placed into separate, properly labeled and sealed, clear plastic bags or containers as appropriate.

c. Each sealed bag/container must be individually labeled with the following information

i. Radiation program number

ii. User name

iii. Isotope

iv. Activity

v. Date

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d. Animal carcasses, organs and tissues should be kept frozen until WMS pick it up.

e. Contact WMS, x1384, if your waste is difficult to package or seal, or for assistance with packaging.

3. **Stocks** – the original vial in which the radioisotope was received.

a. Stock vials must be segregated by isotope, not half-life.

b. Multiple stock vials, containing the same isotope, may be consolidated in a properly labeled and sealed clear plastic bag.

c. Each stock vial or sealed bag must be properly labeled with the following information.

i. Radiation program number

ii. User name

iii. Isotope

iv. Activity

v. Date

d. Stock vials are kept separate from all other radioactive waste. **DO NOT** place stock vials into the solid radioactive dry waste.

4. **Radioactive Liquid Waste** - consists of non-hazardous buffers, salts, and water. No hazardous compounds shall be placed into these containers. The pH of the contents of each radioactive liquid waste container should be between 5 and 9, and must not exhibit any characteristic hazards such as flammability, toxicity, or corrosivitity.

a. *Bulk radioactive liquid waste* is collected in 5 gallon carboy containers, supplied by WMS. Each carboy should be isotope specific and limited to the following activity per 5-gallon carboy containers. Deviations must be approved by WMS.

C-14	2 millicuries
H-3	3 millicuries
S-35	4 millicuries
I-125	1 millicurie
Cr-51	1 millicurie

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P-33	1 millicurie
P-32	1 millicurie
In-111	1 millicurie

b. *Radioactive reagent waste* is generally low-volume, high-activity solutions that do not meet the activity requirements for bulk radioactive liquid waste. Reagent waste is generally collected in smaller poly-carbonate bottles (one liter and smaller) and must be isotope specific. No hazardous compounds shall 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.

c. Each time liquid waste is added to the carboy or reagent bottle, the Radioactive Liquid Waste Log (Liquid Radioactive Waste Disposal Sheet) must be completed and signed. The Radioactive Liquid Waste Log must be attached to the waste container and contain the following information.

   i. User name

   ii. Radiation program number

   iii. Isotope

   iv. Activity

   v. Chemical name

   vi. Amount (liters or kilograms)

   vii. Certification signature

   viii. Date

d. 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.

e. The Liquid Decay Storage Facility (LDSF) reduces disposal costs and liability by decaying waste containing only P-32. Isotope-specific carboys, funnels, and equipment are provided to participating radiation programs. If your program can isolate P-32 liquids, please call X1384 for more information.

f. **DO NOT** place solid dry radioactive waste into liquid waste containers.

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5. **Scintillation Vials** may or may not contain radioactivity.

   a. Non-hazardous scintillation cocktail should be used whenever possible to avoid generating mixed waste. The warehouse stocks non-hazardous scintillation fluid. If this does not suit your needs, please contact WMS for assistance.

   b. All scintillation vials must be segregated based on the following.

      i. Scintillation vials, containing only H-3 and/or C-14, with an average of less than or equal to 0.05 microcurie per gram or 3 x 10^4 cpm/ml for each vial may be grouped together.

      ii. Scintillation vials containing isotopes with a half-life greater than 100 days that do not meet the concentration limit above must be segregated by isotope.

      iii. Scintillation vials, containing isotopes with a half-life of less than 100 days (i.e. P-32, S-35, P-33, etc.), must be segregated by isotope. The WMS requests scintillation vials containing isotopes with a half-life of less than 100 days be stored for decay in the laboratory.

      iv. Scintillation vials that are "background" (Do Not contain any radioactive material) shall be segregated from all other scintillation vials.

   c. All scintillation vials must have a properly completed Hazardous Waste Tag attached identifying the scintillation fluid and total volume of fluid.

   d. All scintillation vials containing radioactive material must be clearly labeled as radioactive with the trefoil symbol and the words "Caution Radioactive material" and the following information.

      i. Radiation program number

      ii. User name

      iii. Isotope

      iv. Activity

      v. Date

6. **Mixed Waste** is radioactive waste that also contains chemical hazards or exhibits any characteristic hazards such as flammability, toxicity, or

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corrosivitity. Common chemicals include methanol or other solvents, acids, bases or metal salts such as lead or barium.

a. Every effort should be made to **NOT** generate mixed waste.

b. If the science dictates that mixed waste will be generated, WMS must be consulted prior to performing the experiments.

c. If mixed waste is accidentally generated, segregate it from all other waste and contact WMS as soon as possible.

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

8. To schedule a radioactive waste pickup, contact WMS either by e-mail nciradwaste@mail.nih.gov or call X1384 and leave your name, telephone extension, building and room number, program number, and type of waste, including isotope and activity.

9. For more information on the disposal of radioactive waste, 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 MDE-279, Notice to Employees, Section 206, Energy Reorganization Act, 1974 and a notice indicating the location for inspection of the following:

a. MDE regulations

b. MDE license

c. All correspondence relating to the license

3. Radiation caution signs or labels must 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 trefoil symbol

b. The words "Caution-Radioactive Materials"

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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.

O. Food and Drink Policy

1. Never introduce any food or drink into any area in which radioactive materials are authorized to be used or stored, even for temporary storage. This includes desk space located in a laboratory that is authorized for radioactive material use.

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

3. Never pipette by mouth.

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

P. Radioactive Material Sink Policy

1. NO radioactive material may be disposed through the sanitary sewer. Any radioactivity above background levels in any sink at the ATRF is in direct violation of MDE 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 V:M Disposal of Radioactive Material of this manual.

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.

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

3. 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. Ensure all personnel have been evacuated from the hazard area.

   b. Restrict entry into the spill area.

   c. Ensure all serious injuries receive medical attention.

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

      i. The most important aspect of decontaminating personnel is speed.

      ii. Remove all contaminated clothing and monitor the body for areas of contamination.

         1. If the contaminated area is small, begin decontamination immediately in the laboratory.

         2. If the contaminated is large, and the individual should be immediately taken to the emergency shower.

      iii. Contaminated areas must be gently washed with soap and water. **DO NOT** use a brush or an abrasive.

      iv. Affected areas should be dried and re-monitored for contamination.

      v. This procedure should be repeated no more than four times.

      vi. If contamination persists, the physician at OHS, **X1096**, should be contacted.

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vii. 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. **DO NOT** use organic solvents.

viii. All contaminated clothing must be placed in a plastic bag and properly labeled for decay (if the isotope involved has a short enough half-life) or disposal. The RSO/RSS shall be notified and the clothing biologically decontaminated if necessary.

e. Evaluate the hazard area.

f. Supervise and/or assist with the decontamination of the spill area.

i. If biological materials are involved, the biological decontamination or sterilization must be performed before radiation decontamination. Only biological decontamination methods approved by the Biological Safety Office are to be used.

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

g. Perform post-decontamination monitoring.

h. Ensure any areas of non-removable contamination are properly shielded/covered and labeled.

i. Return the laboratory to normal operating conditions.

j. Investigate the cause of the incident as well as actions taken to prevent a future incident.

k. Properly document the incident, decontamination procedures and any follow-up.

4. 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 dosimetry and protective equipment as instructed by the RSO/RSS and the physician.

B. Fires or Explosions Involving Radioisotopes

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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. As appropriate, 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 Frederick County Fire and Rescue Services will:

    a. Work with the Radiation Safety Office in identifying the location of all radiation areas, and notify the RSO/RSS whenever a fire involves radioisotopes.

    b. As appropriate, wear dosimetry and respiratory equipment when responding to an incident where radioactive materials are used.

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APPENDIX A

Isotope Information Sheets

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APPENDIX B

Annual Dosimetry Report General Information

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APPENDIX C

NRC Regulatory Guide 8.13

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APPENDIX D

Form MDE-279, Notice to Employees

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APPENDIX E

Section 206, Energy Reorganization Act, 1974

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VIII. Forms

A. Radioisotope Program Application
B. Radioisotope Training and Experience Form
C. X-Ray Program Application
D. X-Ray Program Users Application Form
E. Electron Microscope Program Application
F. Electron Microscope User Application Form
G. Irradiator Users Application Form
H. Radioactive Material Accounting Record
I. Radioactive Dry Waste Log Sheet
J. Liquid Radioactive Waste Log Sheet
K. Hazardous Waste Tag
L. Declaration of Pregnancy Form
M. Form to Withdraw Pregnancy Declaration
N. Request for Consideration as a Dormant Radiation Program
O. Monthly Non-Use Certification
P. Request to Return to Active Radiation Program Status
Q. Contamination Survey Form

IX. Links

A. ATRF Radiation Safety Training for New Users
B. ATRF Annual Radiation Safety Refresher Training
C. Maryland Department of the Environment, Radiological Health Program
D. US Nuclear Regulatory Commission
E. Health Physics Society