

MANUAL FOR THE SAFE HANDLING OF IONIZING RADIATION SOURCES

AT THE WORCESTER FOUNDATION FOR EXPERIMENTAL BIOLOGY

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## INTRODUCTION

The radioisotopes used at the Worcester Foundation are procured and handled under special licenses issued by the U. S. Nuclear Regulatory Commission (NRC). This manual summarizes and interprets the regulations governing these licenses as established by the NRC and the Massachusetts Department of Labor and Industries. The responsibility for proper handling of radiation sources is shared by the Radiation Safety Committee, the Radiation Safety Office, laboratory supervisors, and individual employees. Cooperation between all of these groups is essential to the continued safe handling of all radiation sources. The basic rights and responsibilities of each of these groups is outlined below.

### RADIATION SAFETY COMMITTEE

The Radiation Safety Committee is responsible for directing the use of ionizing radiation-producing materials at the Worcester Foundation. The objectives of this Committee are:

To assist in obtaining radioactive materials and ionizing-radiation producing devices for the use of Scientists at the Worcester Foundation.

To advise upon and control their use in accordance with safe practices as stipulated in the regulations of the NRC and the Massachusetts Department of Labor and Industries.

We are responsible for all radioactive material within the Foundation at all times and are required to allow only fully qualified individuals to handle ionizing radiation sources. We are required to keep track of all radioisotopes whether they are being used, stored, disposed of as waste or in animal carcasses. At the same time we are responsible for the health and safety of every individual within this institution. This is necessary not only for the obvious health and safety issue, but also in order to protect our privilege to handle radioactive material. Please cooperate with us. It is the only way we can maintain Byproduct Material Licenses for YOUR convenience. At present the Radiation Safety Committee is composed as follows.

### RADIATION SAFETY COMMITTEE

Earl Baril, Ph.D.	Chairman
Joseph Bakanauskas, M.S.	Radiation Safety Officer
Peter K. Chin	Consultant Health Physicist
Paul Kennedy	Purchasing Manager
Edward Klaiber, M.D.	Senior Scientist
Yutaka Kobayashi Ph.D.	Consultant in Nuclear Instrumentation
Clifford McDonald	Laboratory Instrumentation Technician
Clare O'Connor, Ph.D.	Staff Scientist
Mina Rano	Executive Secretary
George Witman, Ph.D.	Senior Scientist
Walter Zydlewski	Technical Services Manager

This Committee meets once each calendar quarter or more often if necessary.

### RESPONSIBILITIES OF LABORATORY SUPERVISORS

Laboratory supervisors are expected to be thoroughly familiar with the rules and regulations and are responsible for seeing that all applicable rules and regulations are enforced in their work areas. Generally, they are responsible for seeing that:

- 1) The Radiation Safety Committee is informed of all changes in their work with radioactive materials which might change the possibilities of personnel exposure or release to the environment.
- 2) All use is consistent with the goal of maintaining radiation doses as low as reasonably achievable.
- 3) Radioactive materials are obtained and radioactive wastes disposed of only through proper channels.
- 4) An up to date inventory of the laboratory's radioactive material is maintained.
- 5) The volume of radioactive waste generated is minimized.
- 6) All workers are properly trained and aware of their rights and responsibilities.
- 7) Spills and/or releases of radioactive materials are promptly reported to the Radiation Safety Office.
- 8) All necessary safety equipment and supplies are present and in good working order.
- 9) All required records are kept up to date.
- 10) All routine wipe tests and surveys are performed in a timely manner.
- 11) Obtaining specific permission from the Radiation Safety Office prior to each use of 100 millicuries of 3-H or 10 millicuries of any other radionuclide.



## WORKERS' RIGHTS AND RESPONSIBILITIES

This section outlines the general rights and responsibilities of the individual employee. Further information is available in Title 10 CFR parts 19 and 20 and on form NRC 3 which are available from the Radiation Safety Office. In general, all employees have the right to have their work situation set up so that radiation doses are held as low as reasonably achievable consistent with the amounts and types of radiation sources being used and are responsible for seeing that:

- 1) Each use of radioactive material is consistent with the principle that radiation doses are held as low as reasonably achievable.
- 2) All violations of the rules and/or situations which may lead to an unnecessary radiation exposure are promptly reported to the Radiation Safety Office or Radiation Safety Committee.
- 3) All of the general safety rules plus any special rules applicable to specific procedures are followed.
- 4) Radiation Safety is notified of all emergencies or unusual occurrences involving radioactive materials.
- 5) The generation of radioactive waste is held to a reasonable minimum.
- 6) Before beginning work with radioactive material, they are familiar with all applicable rules and regulations and are familiar with the specific requirements pertaining to a specific procedure.
- 7) Women who work with radiation sources are required to report pregnancies to the Radiation Safety Office.



## RADIATION SAFETY OFFICE

The Radiation Safety Office is staffed with employees of the Foundation and UMMC. The staff functions as the day to day working arm of the Radiation Safety Committee and are available during normal working hours by calling the telephone numbers posted in your laboratory. A representative may be contacted during off hours by calling the appropriate emergency number posted in your laboratory. In general the Radiation Safety Office is responsible for all of the following.

- a. Registering workers who will be involved in the handling of radioactive materials.
- b. Providing, as necessary, personnel monitoring for radiation exposure.
- c. Providing, as necessary, radioisotope laboratory inspection, radiation surveys , and area monitoring.
- d. Collecting, packaging, and disposing of radioactive waste.
- e. Determining that adequate radiation safety instruments are available and properly calibrated.
- f. Leak testing of sealed sources.
- g. Ordering all radioactive materials.
- h. Monitoring all shipments of radioactive materials (both into and out of the institution).
- i. Following-up radiation incidents and supervising special decontamination operations.
- j. Maintaining required radiation protection records.
- k. Performing the initial review of all proposed uses of radiation sources.
- l. Performing the initial review of Investigators' qualifications.
- m. Training personnel in the basics of radiation protection.
- n. Storing bulk quantities of radioactive material.

## OBTAINING AUTHORIZATION TO USE RADIATION SOURCES

The use of ionizing radiation sources is limited to individuals who by virtue of training and experience have demonstrated that they can use such sources in a proper manner. Authorization for possession and use is issued by the Radiation Safety Committee (RSC) after the investigator has submitted a written request detailing which sources are to be used. The application must include an explanation of the procedures to be followed and documentation of the investigators training and experience. Preliminary review of the application will be performed by the Radiation Safety Office and at that point temporary authorization to use up to 10 times exempt quantities may be issued. The RSC receives the application and the Radiation Safety Office's preliminary review and votes to deny or issue authorization. The RSC reserves the right to impose, at any time, any special conditions it deems necessary to insure that radiation sources are used in a proper manner. The RSC may meet by letter ballot and the review of an application to use small amounts of radioactive material in simple wet procedures may be processed in as little as a week. More complex applications typically require a longer period for review. Requests for changes in existing authorizations are to be made in writing and follow the same route.

Examples of exempt quantities of radioactive material are:

- 1000 microcuries of 3-H or 51-Cr
- 100 microcuries of 14-C, 35-S, or 85-Kr
- 10 microcuries of 32-P, 45-Ca, or 75-Se
- 1 microcurie of 125-I or 131-I

## OBTAINING RADIOACTIVE MATERIAL

The Foundation may possess only certain radionuclides and for each allowed radionuclide there is a possession limit. Exceeding these possession limits may lead to severe repercussions and adversely effect your privilege of using radioactive material. To assure that these limits are not exceeded, all requests for radioactive material whether from a commercial vendor or as a transfer from another license must pass through the Radiation Safety Office. The Radiation Safety Office will then pass the requisitions through normal channels as expeditiously as possible.

## RECEIPT OF RADIOACTIVE MATERIAL

All packages of radioactive material will be received at the stockroom where they will be checked for removable contamination and the dose rates at the surface and one meter from each package will be checked for compliance with appropriate regulations (NRC & DOT). While almost all of our incoming shipments are exempt from this requirement pursuant to 10 CFR 20.205, all incoming shipments will be checked and we will not arrange for shipments to be delivered directly to a laboratory. In the event that a shipment is found to be in violation of the shipping requirements the Radiation Safety Officer must be notified immediately. The Radiation Safety Officer will confirm the readings and if necessary inform the carrier and the appropriate regulatory agencies.

If the shipment meets specifications the purchaser will be notified by telephone to pick it up at the stockroom. Unless arrangements have been made with Radiation Safety for appropriate storage unclaimed shipments will be disposed of as waste. Before discarding of the packaging material all of the warning labels must be removed or defaced and the boxes checked for contamination. Please note that shielding used for transportation may not be adequate for storage and measurements should be made to determine whether additional shielding is needed.

## ADMINISTRATION TO HUMANS

Our Byproduct Materials license does not allow the deliberate administration of radioactive material or the radiation therefrom to human subjects.

## MINORS AND PREGNANT WOMEN

Federal law prohibits any individual younger than 18 to be employed as a radiation worker. Minors are not allowed to use radiation sources.

Pregnant women are required, as are all employees, to take every reasonable precaution to minimize their own radiation dose. This requirement exists for the protection of the fetus as well as the employee. Pregnant women are required to notify the Radiation Safety Office of their pregnancy. Radiation Safety office personnel and the Radiation Safety Committee will provide pregnant women with information, advice and counseling and will work with them to minimize the radiation dose to the fetus. Any pregnant woman, at her request, will have her work situation changed so as to eliminate work with radioactive material and/or ionizing radiation sources.

## General Precautions

- 1) Protective clothing is to be worn. Generally lab coats are sufficient, but for special procedures additional protection may be needed. Please consult Radiation Safety.
- 2) Personnel dosimetry (badges) is to be used where a significant external exposure possibility exists.
- 3) Wear gloves. Double gloves are recommended for higher level procedures.
- 4) Eating, drinking, smoking, mouth pipetting, application of cosmetics and storage of food stuffs are prohibited where unsealed radioactive materials are used or stored.
- 5) Use appropriate shielding during operations and storage.
- 6) Plan all operations employing time, distance, and shielding to minimize radiation exposure.
- 7) Wash your hands after each use of radioactive material.
- 8) Adequate ventilation is to be used when the likelihood of airborne radioactive material exists.
- 9) Bench tops should be protected with removable absorbent material.
- 10) Use survey meters often to check for contamination and adequacy of shielding.
- 11) Use remote handling devices to manipulate "hot" (contact dose rate > 1 rem/hour) sources.



### SEALED SOURCES

A number of sealed sources are used for instrument calibration or for gas chromatography detectors. The following procedures must be followed:

- (a) The sources should not be handled.
- (b) Film badges must be worn when working with Strontium-90 or Cobalt-60.
- (c) Tritium sources must not be subjected to over 225 C.
- (d) Sealed sources must not be removed from their encapsulation
- (e) Sealed sources are wipe-tested every six months by Radiation Safety to assure their integrity.

### RESTRICTED AREAS

The halls and corridors of the Foundation are unrestricted areas. Radioisotopes should not be handled in those areas. Transporting radioisotopes from one laboratory to another through such areas should only be done after the radioisotope is properly packaged and shielded. The Radiation Safety Office must be notified immediately in writing on a transfer form of any transfers of radioisotopes from one supervisor to another within the Foundation.

### STORAGE

All stock solutions of radioisotopes in liquid form or in solution must be stored in glass bottles placed in outer unbreakable containers large enough to catch any spills in case of breakage. Liquid radioactive waste is to be stored in plastic containers unless the solvents are not compatible with plastic.

### REFRIGERATORS AND FREEZERS

All refrigerators and freezers in which flammable liquids are stored must be made explosion proof by removal of light, switch and thermostat control.

Any refrigerator or freezer in a non-restricted area, such as hallways, must be locked. All refrigerators are to be posted with the proper NRC signs and the name and phone number of the supervisor, and an inventory which is updated every month.

### LABELLING

A list should be posted on each refrigerator and laboratory noting the types and amounts of isotopes contained therein. This should be updated each month.

Laboratories using radioisotopes must have the prescribed NRC signs (CAUTION RADIOACTIVE MATERIAL) prominently displayed on all entrance doors. Each storage container must have the proper label affixed (CAUTION RADIOACTIVE MATERIAL, AMOUNT, DATE, KIND). Containers in use may have temporary tags.

### BIOASSAYS

Individuals using 1 millicurie or greater quantities of radioiodine must have thyroid monitoring performed within 72 hours of said use. Monitoring is performed with a portable instrument equipped with a Ludlum Model 44-3 probe. This service is available to individuals working with smaller amounts of radioiodine.

Following each use, urinalysis will be performed on all individuals handling 25 millicuries of any radioisotope. Urinalysis will be required for individuals working with smaller quantities of radioactive material if the nature of the work or the chemical or physical form indicates that volatility, aerosols or dusts may be a problem. This service is available to individuals working with smaller quantities of radioactive materials.

### SUPPLIES

The following isotope handling supplies are available from the Radiation Safety Office in Room 42, Wing B, Building 6.

- absorbent tray liners
- paper lab coats
- plastic gloves
- plastic shoe covers
- plastic bags
- radioactive labels and signs
- shipping containers
- waste cans
- extra cans
- extra survey meters
- dosimeters
- keys to the radioactive animal room
- batteries for meters
- breath analysis and urinalysis supplies
- extra forms as required
- temporary film badges
- plastic-coated absorbent paper
- wipe tests
- film badge services
- waste disposal

## EMERGENCY PROCEDURES

There is a decontamination kit, extra survey meters, dosimeters, a rate meter and other supplies in the Radiation Safety Office.

### ACCIDENTS INVOLVING RADIOACTIVE DUSTS, MISTS, FUMES, ORGANIC VAPORS, AND GASES

1. Notify all other persons to vacate the room immediately.
2. If the task can be performed easily and safely, hold breath and close air vents.
3. Vacate the room, seal off area, if possible.
4. Notify the Radiation Safety Office at once.
5. Ascertain that all doors giving access to the room are closed. Post conspicuous warnings or guards to prevent accidental opening of the doors.
6. Monitor all persons suspected of contamination. Proceed with decontamination of personnel.
7. Report at once to the Radiation Safety Officer all known or suspected inhalations of radioactive materials.
8. Evaluate the hazard and the safety devices necessary for safe reentry.
9. Determine the cause of contamination and rectify the condition.
10. Decontaminate the area only upon the advice of the Radiation Safety Officer.
11. Perform an air survey of the area before permitting work to be resumed.
12. Submit a complete history of the accident and subsequent activities to the Radiation Safety Officer.

### MAJOR SPILLS, INVOLVING RADIATION HAZARDS TO PERSONNEL

1. Notify all persons not involved in the spill to vacate the room at once. Limit the movement of displaced persons to confine the spread of contamination.
2. If the spill is liquid and the hands are protected, right the container; otherwise, use a stick or lever.
3. If the spill is on the skin, flush thoroughly.
4. If the spill is on the clothing, discard outer or protective clothing at once.
5. Switch off all fans.
6. Vacate the rooms.
7. Notify the Radiation Safety Officer as soon as possible.
8. Take immediate steps to decontaminate personnel involved as necessary.
9. Decontaminate the area (personnel involved in decontamination must be adequately protected). The Radiation Safety officer will direct the decontamination.
10. Monitor all persons involved in the spill and cleaning.
11. Permit no person to resume work in the area without the approval of the Radiation Safety Officer.
12. A complete history of the accident and subsequent activity must be submitted to the Radiation Safety Officer.



MAJOR SPILLS, INVOLVING NO RADIATION HAZARD TO PERSONNEL

1. Notify all other persons in the room and area at once.
2. Survey people before they become dispersed, and change clothes as necessary.
3. Permit only the minimum number of persons necessary to deal with the spill into the area.
4. Confine the spill immediately.
  - A. Liquid spills: Don protective gloves, drop absorbent paper on spill.
  - B. Dry Spills: Don protective gloves. Dampen area thoroughly taking care not to spread the contamination. Water may generally be used, except when chemical reaction with the water would generate an air contaminant; oil should be used instead.
5. Decontaminate, make a plan first, contact the Radiation Safety Officer.
6. A complete history of the accident and subsequent remedial or protective measures must be submitted to the Radiation Safety Officer.

INJURIES TO PERSONNEL INVOLVING RADIATION HAZARD

1. Wash minor wounds immediately under running water, spreading the edges of the gash.
2. Report all radiation accidents involving personnel (wounds, overexposure, ingestion, inhalation) to the Radiation Safety Officer as soon as possible.
3. Call at once a physician qualified to treat radiation injuries.
4. Permit no person involved in a radiation injury to return to work without the approval of the attendant physician and the Radiation Safety Officer.
5. Prepare a complete history of the accident and subsequent activity related thereto for the Radiation Safety Officer.

## DECONTAMINATION TECHNIQUES

Decontamination techniques are needed for personnel and areas. In cleaning objects and areas, the initial step depends on whether the contaminant is in powder or liquid form. If the material is dry or powdered, vacuuming is a most valuable technique, since much adherent material can be removed, lessening the chance for penetration into the surfaces when wetting agents are applied. A suitable method of filtration of effluent air from the vacuum cleaner must be provided, so that there is no further spread of radioactivity. Damp wiping and mopping with water and detergent are the next steps. If the chemical characteristics of the contaminant are not known, detergents of neutral pH are preferable to soaps, which - in some instances - may cause fixation of certain nuclides rather than removal. Complexing agents, e.g., citric acid or chelating agents (EDTA or DTPA) in combination with detergent or soap increase the cleaning efficiency; the action of chelating agents is accelerated by warming. Occasionally, dilute hydrochloric or nitric acid may be of value. The procedure for decontamination is given below.

### Preoperational

1. Plan the decontamination operation thoroughly, and obtain supplies.
2. Provide adequate protection for all decontamination personnel, and allow for replacements.
3. Provide safe storage of all radioactive wastes and decontamination supplies.

### Operational

1. Always work towards the center of contamination.
2. Take care not to spread or track contamination to cleaner (lower activity) areas.
3. Monitor frequently and thoroughly.
4. Cover clean areas with plastic sheets, kraft paper, or its equivalent.
5. Monitor all personnel and materials before permitting their movement to clean areas.

### Postoperational

1. Quarantine all used cleaning solutions and decontamination equipment until they can be monitored.

### FIRES AND OTHER MAJOR EMERGENCIES

It is difficult for fire and police officials to evaluate accurately the magnitude of a radiation risk at the time of an emergency so we have posted in the Radiation Safety Office, Wing B, Room 42, a magnetic board with the amounts and types of isotopes in use in each laboratory. Also, there is a glass case mounted on the wall with a map of the Foundation and the distribution of isotopes shown in colored pins. These are kept up-to-date for emergency use and information.

1. Notify all other persons in the room and building at once.
2. Notify the fire department and other local plant safety personnel as well as the Radiation Safety Officer.
3. Attempt to put out fires by approved means if radiation hazard is not immediately present.
4. Govern fire fighting or other emergency activities by the restrictions of the Radiation Safety Officer. Avoid, if possible, the tracking of contamination or passing of contaminated equipment into clean areas by emergency workers.
5. Monitor all persons involved in combating the emergency.
6. Following the emergency, monitor the area and determine the protective devices necessary for safe decontamination.
7. Decontaminate, follow a plan.
8. Permit no person to return to work without the approval of the Radiation Safety Officer.
9. Prepare a complete history of the emergency and subsequent activity related thereto for the Radiation Safety Officer.



### BADGES

Each month, all personnel whose work situation indicates the possibility of receiving 10% of a maximum permissible radiation dose will be issued commercially processed personnel dosimetry consisting of film badges for monitoring body exposure and ring badges for monitoring hand exposure. These badges are considered an essential part of the Radiation Safety Program and must be worn when working with significant amounts of gamma or hard beta emitters. Personnel working in situations with a lower risk of radiation exposure may be issued other types of dosimetry such as direct reading pocket dosimeters or TLD badges and the exchange rate may be less frequent (quarterly).

### RADIOACTIVE WASTE

Treatment and disposal of radioactive waste are labor intensive and costly procedures. In accordance with the national effort to minimize the amount of waste shipped to the existing burial grounds for disposal. Personnel at the Foundation are expected to employ all legal and environmentally sound waste volume reduction techniques. Generally these include careful planning of experimental procedures so as to minimize the generation of radioactive waste including purchasing and using the minimum amount of radioactive material needed for experimental purposes, using "minivials" and "deregulated" cocktail for liquid scintillation counting, and being exceedingly careful to keep radioactive and general waste separate. Following the procedures outlined below will allow us to process radioactive waste in such a manner that we can 1) minimize the volume shipped for burial and 2) package what must be shipped in a legal manner. We are dependent on your cooperation and remind you that all research involving the use of radioactive material is dependent on safe and legal disposal of the waste. For some laboratories this may necessitate the use of 2 or more separate containers for the solid waste and the same number for the liquid waste. As best as possible the Radiation Safety Office will assist the investigator in selecting appropriate containers.

### GENERAL INFORMATION

All Radioactive waste is picked up, processed, packaged and disposed of by UMMC personnel on a weekly or as needed basis. All waste is to be labeled with the investigators name, the radionuclide(s) present and the amount of each radionuclide present. When short lived nuclides ( $t_{1/2} < 3$  months) are present, the date the waste was placed in the container must also be entered. If any of the materials in the radioactive waste are reactive or toxic they must also be noted on the label.

### LIQUID SCINTILLATION VIALS

These are to be sorted into two major groups based upon the type of cocktail used. Group I consists of vials in which the cocktail is a deregulated type or water. Group II consists of vials using a cocktail containing a regulated solvent such as xylene, toluene or dioxane. Within each major category the vials are to be subgrouped by isotope in the following manner.

- Subgroups - A. Vials containing only 3-H and 14-C at a concentration of less than 0.05 microcuries (111,000 DPM) per gram.
- B. Vials containing only nuclides with a half-life of 90 days or less
- C. Vials containing nuclides with a half-life longer than 90 days

### LIQUID RADIOACTIVE WASTE

For all of the categories listed below it is extremely important that any and all reactive and/or toxic materials be listed on the waste labels. Laboratory personnel are prohibited from disposing of liquid radioactive waste into the sanitary sewer system. Glassware rinsings are an exception to this rule.

For purposes of volume reduction, the liquids may be mixed and evaporated to almost dryness. We are particularly concerned with the formation of azides, fulmanates and nitrates. We would not like, for example, to mix glycerol with nitrite and sulfuric acid and then concentrate the mix. With the exception of wastes which will pass through or dissolve the plastic, all liquid radioactive waste is to be collected and stored in labeled plastic jars without absorbent. If glass or brittle plastic containers must be used, they must be stored and transported inside a nonbreakable outer container such as a bucket.

Liquid radioactive waste is to be segregated into two major categories. The first is aqueous liquids, the second is non-aqueous liquids. Within each of the major categories liquid waste is to be sorted by half-life. The subgroupings are:

- A. Only nuclides with a half-life of under 15 days
- B. Nuclides with a half-life longer than 15 days but shorter than 91 days
- C. Nuclides with a half-life of 91 days or longer

Experiments should be designed so as to minimize the generation of wastes containing a mix of short and long lived radionuclides.

### SOLID WASTE

Dry solid waste is to be placed only in plastic lined containers clearly marked "Radioactive" and a separate container is to be used for each category of radionuclides listed below. "DRY" solid waste may contain no more than 0.5% liquid so that while a few microliters of liquid in each test tube may not be of concern, just a few centrifuge tubes containing 5 to 15 milliliters of liquid are a matter of concern. These should be emptied into the liquid waste prior to disposal of the container as solid.

Categories - I - long lived ( $t_{1/2} > 90$  days) radionuclides such as 3-H & 14-C.

II - radionuclides for long term decay ( $15 < t_{1/2} < 91$  days) such as 125-I.

IV - radionuclides for short term delay ( $t_{1/2} < 15$  days) such as 32-P & 131-I.

As with other types of waste, the contents of the solid waste buckets must be listed.

### RADIOACTIVE ANIMALS

Before starting any experiments with radioactive material in animals, each investigator must notify the Radiation Safety Office on the proper form. All such experiments must be carried out in the radioactive Animal Rooms unless otherwise permitted by the Radiation Safety Office.

Each investigator is responsible for cleaning of cages and trays. Refuse is to be placed in plastic bags and stored in the freezer near room 5-67. A tag listing the investigator's name, the amount of each radionuclide, and the date must be tied to each cage and to each bag of animal carcasses in the freezer. These tags are available in the radioactive Animal Rooms. Routine instrument surveys and wipe tests are to be performed.

Animal carcasses and tissues containing only 3-H and 14-C at a concentration of less than 0.05 microcuries per gram may be disposed of as nonradioactive pathological waste with the permission of the Radiation Safety Office. Such "deminimus" disposals must be noted in the radioactive waste records.