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# Section I

## Philosophy of Radiation Safety at the University of Wisconsin - Whitewater

The use of radioactive materials provides a powerful tool in education and in research. The goal of the University of Wisconsin-Whitewater (UWW) radiation safety program is to protect the users, their co-workers, and the general public from exposure to excessive levels of radiation and concentrations of radioactive materials. Use of ionizing radiation sources is performed in accordance with State and Federal regulatory requirements. Members of the UWW faculty may continue to possess and use radioactive materials because the university holds a "Materials License" from the U.S. Nuclear Regulatory Commission (NRC). Copies of the UWW radioactive materials license and pertinent State and Federal regulations are available for reading to those interested; copies are on file in the Office of Risk Management and Safety, the office of the Provost, and the office of the Radiation Safety Officer.

"The U.S. Nuclear Regulatory Commission (NRC) is an independent agency established by the U.S. Congress under the Energy Reorganization Act of 1974 to ensure adequate protection of the public health and safety, the common defense and security, and the environment in the use of nuclear materials in the United States. The NRC's scope of responsibility includes regulation of:

- commercial nuclear power reactors; non-power research, test, and training reactors
- fuel cycle facilities; medical, academic, and industrial uses of nuclear materials
- the transport, storage, and disposal of nuclear materials and waste."

From the U.S. NRC web site, "About NRC", http://www.nrc.gov/NRC/about

From the U.S. NRC web site, "Mission and Organization: Mission", http://www.nrc.gov/NRC/WHATIS/mission

"The NRC and its licensees share a common responsibility to protect the public health and safety. Federal regulations and the NRC regulatory program are important elements in the protection of the public. NRC licensees, however, have the primary responsibility for the safe use of nuclear materials."

From the U.S. NRC web site, "Mission and Organization: Statutory Authority", http://www.nrc.gov/NRC/WHATIS/mission

The policy of UWW is to maintain occupational and instructional radiation exposure "As Low As Is Reasonably Achievable" (ALARA). The rules and procedures contained in this manual are designed to implement this operating philosophy. Furthermore, all approved uses of ionizing radiation on campus are expected to comply with this policy by making every effort to reduce radiation as far below the specified limits as is reasonably achievable by means of good radiation protection, planning, and practice.

The objective of this manual is to provide the user of ionizing radiation sources with a ready reference to regulatory agency requirements, UWW risk management and safety program, and the responsibilities and operating procedures relevant to the use of radioactive materials. The various sections explain terms used in radiation protection, assist in calculation of radiation exposure and shielding requirements, and describe the standards for the radiation workplace. Additional training materials are available describing the safety precautions to be used when handling specific radioisotopes.

The policies of UWW also mandate compliance with the Safety and Health Policy Statement of the University of Wisconsin System Board of Regents. "The University of Wisconsin System will provide and maintain adequate facilities for a safe and healthy learning environment. It is the University's responsibility to work with faculty and staff so that they are equipped to educate their students on practices and procedures that ensure safety for all members of the university. Employees with instructional responsibilities are expected to comply with state and federal safety laws and regulations in their institutional areas. Certain courses and research projects require that the student work with hazardous materials while engaging in academic studies. Instructors of these courses and research projects shall inform and train students on procedures that will maintain the students' personal health and safety and provide them with information on the hazards of specific chemicals that will be used during their course of study. Furthermore, instructors will enforce and follow safety policies. Prior to use of hazardous materials and equipment, the student shall review the procedures and information, and discuss any associate concerns with the instructor."

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# Section II

### People - the Program of Radiation Safety at UWW

## A. Organization of the Safety Program

Members of all levels of the UWW community must take responsibility for safety. On a daily basis, the authorized users (AU's), faculty members who have training and experience with the specific radioactive materials with which they teach and/or do research, must drive radiation safety efforts. (The latter individuals are also called Primary Investigators or PI.) In addition, students participating in classes or research under the direct supervision of an AU/PI must be trained and diligent in the safe use of radioactive materials.

On a campus-wide scale, the leaders in radiation safety are the Radiation Safety Officer and the Hazardous Waste and Radiation and Biological Safety Team. The Radiation Safety Officer (RSO) is charged with the responsibility for radiation safety on the UWW campus. The RSO reports to the director of the Office of Risk Management and Safety, who then reports to the Vice Chancellor for Administrative Affairs with consultation with the Provost. The Hazardous Waste and Radiological and Biological Safety (HWRBS), a sub-committee of the UWW Campus Safety Committee, directs the development of campus standards for radiation safety, and it acts to review use of radiation on campus. The HWRBS has both administrative and advisory functions.

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## B. Office of Risk Management and Safety

"The Environmental Health, Risk Management, Safety and Loss Control Office is a unit in the Division of Administrative Affairs. Our mission is to enhance the teaching, research and scholarly activity at the University of Wisconsin-Whitewater by fostering a safe and healthful work, study, and research environment."

From the UWW EHRMSLC web site, "Mission Statement", http://www.uww.edu/adminaff/rmsms.htm

Additional information on the Office is available on the EHRMSLC home page or via links on that page.

EHRMSLC home page http://www.uww.edu/adminaff/riskmgmt.htm

Campus health and safety policies http://www.uww.edu/adminaff/uwwhsp.htm

Membership of safety teams http://www.uww.edu/adminaff/sfteams.htm

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**C. Hazardous Waste and Radiation and Biological Safety Team (HWRBS)** The Hazardous Waste and Radiation and Biological Safety Team (HWRBS) is an administrative committee consisting of faculty members (both AU and non-AU), a member of the Health Services Staff, and the RSO, who is the Executive Officer. The HWRBS is charged with two major responsibilities.

1. The HWRBS is responsible for the development of uniform radiation safety policy at all UWW facilities, ensuring that the university complies with pertinent State and Federal regulations.
2. The HWRBS reviews all uses of radioactive materials; it thus has the responsibility of reviewing applications from potential AU's, requests for new radioactive materials, and requests for use of new protocols.
3. The HWRBS may also provide advice to the Chancellor, Provost and other administrators on general matters involving radiation safety. Detailed descriptions of the activities of the HWRBS are listed in Table 1.

## Table 1. Activities of the Hazardous Waste and Radiation and Biological Safety Team (HWRBS)

The HWRBS is responsible for policies on the safe use of radioactive materials on the UWW campus. Current membership of the HWRBS can be found at the Web site for membership on campus safety teams http://www.uww.edu/adminaff/sfteams.htm The HWRBS has the responsibility to perform the following duties:

1. 1. Assume responsibility, from the standpoint of radiation safety, for all university programs involving radioactive materials.
    - Radioactive materials refer to all materials, solid, liquid, or gas, that emit ionizing radiation spontaneously.
        - Radiation, as used herein, is X-rays, gamma rays, alpha and beta particles, high speed electrons, neutrons, protons, and other nuclear particles; and microwaves and lasers; but not sound or radio waves or light other than lasers.
        - Radiation safety refers to the safe storage, transport, use and handling of radioactive materials or radiation in any application, including but not restricted to teaching, research, development, and disposal.
2. Review and grant permission for, or disapprove, on the basis of radiation safety, requests for the use of radioactive materials within the institution.
3. Review and prescribe the special conditions, requirements, and restrictions as may be deemed necessary to protect the university personnel and the general population from health hazards associated with radioactive materials on campus. Such conditions, restrictions and requirements shall in all cases be made in accordance with any existing Federal or State regulations. Committee approval of health and safety measures must be obtained before any project involving radioactive materials or radiation producing devices is initiated.
4. Prescribe special conditions and requirements as may be necessary (such as physical examinations, additional training, designation of limited area or location of use, disposal methods, etc.) to assure radiation safety.
5. Evaluate and make appropriate recommendations for the construction of new or remodeled structures in which the use of radioactive materials or radiation producing devices is contemplated. Written approval of proposed building or remodeling plans for such facilities where radioactive materials are in use at the time must be obtained from the HWRBS prior to construction.
6. Direct the preparation and dissemination of information on radiation safety practices and procedures for the use and guidance of staff and students.

7. Approve or disapprove the actions of departmental representatives or departmental committees within the University in matters pertaining to radiation safety. Such actions as are taken by departmental committees shall be submitted to the HWRBS for final approval.
8. Keep a record of the actions in approving the use of radioactive materials and of other transactions, communication, and reports involved in the work of the Committee.
9. At least annually audit the radiation control records maintained by the RSO to insure compliance with regulatory requirements. The audit to be carried out by a three-person audit subcommittee (including the Chairperson) which then reports back to the full committee.

The RSO, as Chairperson of the HWRBS, or another duly authorized representative of the HWRBS, is authorized to act (under policies established by the HWRBS) for the HWRBS between meetings, reporting actions taken to the Committee for review at appropriate intervals.

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**D. Radiation Safety Officer** The Radiation Safety Officer (RSO) is charged with the overall responsibility for radiation safety on the UWW campus. The RSO acts as a facilitator of teaching and research, a watchdog, a liaison among various campus entities (AU/PI, Risk Management, HWRBS, Chancellor and Provost) and between UWW and the NRC. The complexity of the work requires the RSO have extensive training and experience, including:

1. training and experience in a natural science (physical, chemical, or biological science),
2. training and experience with radionuclides (types and quantities listed on the license), &
3. training and experience in a formal course designed for RSO presented by a commercial radiation safety consulting company or other organization approved by the NRC (e.g., academic institution, professional organization of radiation protection experts). The RSO reports to the director of the Office of Risk Management and Safety, who then reports to the Vice Chancellor for Academic Affairs in consultation with the Provost.

Descriptions of specific activities of the RSO are listed in Table 2. Of particular note, as action consistent with the radiation protection of university personnel and the general population, authorization is granted to the RSO to:

1. **Carry out unannounced inspection and radiation surveys of any university facility.**
2. **Order immediate shutdown or cessation of work in any facility where it is evident that radiation hazards exist to the extent that continued operation would result in violation of existing Federal, State, or university regulations.**
3. **Act as the designated contact person for UWW when any local, state or federal radiation inspector visits the campus.**

## Table 2. Activities of the Radiation Safety Officer (RSO)

**A. Typical RSO Duties - General Categories:**

Stop unsafe activities
Supervise decontamination
Ensure security
Control disposal
Interact with NRC and other authorities
Maintain records
Audit program annually
Perform surveys
Train personnel
Investigate abnormal events

**B. Specific duties of the RSO:**

1. Maintain state registration and NRC license to use radioactive materials through preparation and submission of comprehensive applications for license renewal and amendments.
2. Review applications for new uses of radioactive substances to determine if procedures and facilities are in compliance with university and NRC requirements and submit recommendations to HWRBS.
3. Serve as the University's official liaison with regulatory units (U.S. NRC) in matters of registration, licensing, and radiation control, as related to radioactive materials.
4. Serve as chair of HWRBS.

5. Keep appraised of current NRC regulations and guidelines, and review changes and advise HWRBS.
6. Verify all radiation survey instruments are calibrated each six months or after servicing. Approved users shall be responsible for calibrating their own survey instruments.
7. Direct and monitor the disposal and record keeping of all radioactive wastes.
8. Prepare and disseminate information on radiation safety and health physics.
9. Review plans for construction of all new radioisotope facilities and submit recommendations to the HWRBS for action.
10. Approve ordering, receiving, storing, processing, and dispensing of all radioactive materials, including maintaining records of same.
11. Conduct emergency decontamination procedures.
12. Provide overall administrative direction for the university's radiation safety program.
13. Conduct a physical inventory of all radioactive sealed sources each six months.
14. Maintain radiation dosimetry program (film badges or pocket dosimeters) for users should use levels increase. Investigate any detected exposure to determine source and take corrective action.
15. Perform contamination surveys in all laboratories in which radioactive substances are used, at least monthly. Investigate any detectable contamination to determine causes and take necessary action to remove contamination and prevent further occurrences.
16. Perform leak tests every six months of all sealed sources containing radioactive substances over 100 microcuries of beta and/or gamma emitting material or over 10 microcuries of alpha emitting material.
17. Conduct radiation safety training for maintenance and custodial personnel who may need to perform duties in restricted radiation areas. The RSO may also provide sessions for other ancillary personnel, who work near but not in restricted areas, to provide information and allay fears regarding radioactive materials.
18. Review contamination survey reports submitted by approved users and take necessary action.
19. Perform quarterly compliance inspections of laboratories using radioactive materials and take necessary corrective action.
20. Maintain an inventory of all radionuclides and limit the quantity of radionuclides at the university to the amounts authorized by the NRC license.
21. In cases of non-compliance with any radiation safety requirements, the RSO shall issue a written notice to the user with copies to the HWRBS describing the non-compliance and a directive to take corrective action. The user shall report in writing when corrective action is taken. If corrections are not completed within two weeks, the RSO shall issue a second notice with copies to the HWRBS and the user's supervisor. If corrections are not completed within one week of the second notice the RSO shall order immediate cessation by the user of any use of radioactive materials or radiation producing devices.
22. The RSO shall order immediate shutdown or cessation of work in any facility where it is evident that radiation hazards exist to the extent that continued operation would result in violation of existing Federal, State, or university regulations.
23. Supervise radiation safety training for personnel who may need to perform duties in restricted radiation areas. All students working with radiation must have training approved by the RSO prior to beginning work.

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## E. Authorized Users/Principal Investigators

An "Authorized User" (AU; also known as "Principal Investigator" or PI) is a faculty or staff member whose training and experience have been reviewed and approved by the NRC, who is named on the campus materials license, and who uses or supervises use of licensed material in teaching or research. The AU/PI's primary responsibility is to ensure that radioactive materials are being used safely and according to regulatory requirements. In addition, the AU is responsible for ensuring that procedures and engineering controls are used to keep occupational and educational doses, as well as doses to members of the public, ALARA.

### Table 3a. Responsibilities of Authorized User/Principal Investigator (AU/PI)

1. To ensure there is adequate control of radiation sources, the UWW policy is
   a. the responsible AU/PI must be a member of the faculty (tenured, tenure-track, teaching staff),
   2. AU/PI's must submit an application to the HWRBS in advance of use of radioactive materials,

3. each type of use (protocol, radionuclide, etc.) must be reviewed and approved by the HWRBS, &
4. each application for use of radioactive materials must list at least one other user in addition to the AU/PI.

2. Applicants are responsible for preparing complete and accurate applications so that HWRBS review and approval can be accomplished with a minimum delay
3. Applicants are responsible for ensuring that the proposed procedures and facilities reflect laboratory design capabilities
4. At all times, the AU/PI is responsible for ensuring that the radioactive material is used as specified on the application and in compliance with any restrictions on its use by the HWRBS.
5. The AU/PI must provide a safe workplace for all workers, necessary instrumentation and adequate isotope storage. Further, this environment should eliminate exposure of the general public to inappropriate levels of exposure to radioactive materials.
6. The AU/PI must also ensure student users have been approved by the HWRBS or RSO, and are aware of safety and regulatory requirements, and that experimental procedures are in accordance with safety approval requirements.
   a. Approval of student users can be made collectively by the RSO. Specifically, the RSO can grant renewable permission to a faculty member with an established safety record for students enrolled in a particular course.
   2. Approval of student users working with a research mentor is done on an individual basis. The student may be trained by the RSO or by the PI, but records of training and of assessment of training must be made and copies submitted to and kept by the RSO.
   3. The RSO has the authority to revoke student user status when such an individual has demonstrated reckless or otherwise inappropriate behavior in working with radioactive materials.

## Table 3b. Responsibilities of All Users

ALL users are responsible:

1. for knowing the characteristics and potential hazards of the isotopes with which they are working,
2. for ensuring that experimental procedures, applicable regulations and safety procedures are followed,
3. for using required radiation safety instrumentation, dosimeters (when appropriate) and Personal Protective Equipment (PPE);
4. for ensuring that all work is conducted with a regard for the safety of themselves and others.

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## F. Other University Personnel, Students and the General Public

Students and individuals whose assigned duties involve exposure to radioactive material must receive instruction commensurate with their duties and responsibilities. This training must occur before beginning work with licensed material. Each AU/PI must assess each individual for the depth of their previous training, the extent of their anticipated involvement, and then provide adequate training for each applicable subject.

Training may be in the form of lecture, demonstration, videotape, or self-study. There should be an emphasis on practical subjects important to safe use and responsibility to others. The person conducting the training must have appropriate qualifications (e.g., the RSO or selected authorized users who are familiar with the campus program). Documentation of training shall include an outline of topics covered (with indication of method used), a photocopy of the sign-in sheet, a list of qualifications of the instructor, and a statement of assessment method (if written test, a copy shall be included).

Records of training should be kept in the files of the trainee, with copies being retained by the AU/PI and by the RSO. Each individual may need to receive periodic refresher training.

Ancillary personnel (e.g., clerical, housekeeping, security) whose duties may require them to work in the vicinity of radioactive material, whether they are escorted or not in such premises, need to be informed about radiation hazards and appropriate precautions, particularly in the case of emergency situations. Exposure of such individuals is not anticipated; authorized users and the RSO will implement physical and procedural safeguards towards this goal. Members of the UWW community and the general public should be considered as having very low probability of exposure to laboratory sources of radioactive materials (see Table 4).

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## G. Pregnancy Policy

In case of an anticipated or confirmed pregnancy in a female working in a restricted (radiation) area, the following procedures shall be followed:

a. The individual shall inform her supervisor (instructor, research mentor, department chair, or Dean) in writing. A copy of the notice shall be submitted to the RSO.
2. The individual will be requested to read the Appendix to Regulatory Guide 8.13, "Possible Health Risks to Children of Women Who Are Exposed to Radiation During Pregnancy".
3. The supervisor (instructor, research mentor, department chair, or RSO) shall discuss with the individual the precautionary measures she may take to reduce radiation exposure.

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# Section III

### Places - Requirements for Use of Radioactive Materials

Users should consider that exposure to radiation or radioactive materials carries potential danger. The risk can be limited by both physical and behavioral factors. This section describes physical factors - the design of laboratories and work areas to limit exposure of users (and non-users) to radioactive materials. Behavioral factors are described in Section IV. The RSO reviews facilities to aid in compliance with NRC regulations.

## A. Facility Design

1. **Basic definitions**
   - **a. Restricted areas**
     - Restricted areas are defined as areas to which the licensee limits access. This protects untrained individuals against undue risks from exposure to radiation and radioactive materials. This designation may refer to a room, a hood, or a section of a room. A restricted area must be clearly defined, marked and identifiable (see III. B. Communication below). Scaled drawings and sketches should be developed showing the relationship between restricted areas and unrestricted areas and the location of all pertinent safety-related equipment. The map will be posted in the room, used for surveys, reviewed by RSO, made available to emergency personnel. An unrestricted area is one with no restrictions regarding access, and thus one into which no radioactive materials should be placed. Designated areas should be provided for coats and personal belongings, to avoid contamination. Areas with background radiation levels should be designated for personnel dosimetry storage when not in use.
   - **2. Form of radioactive material**
     - Liquid and solid radioactive materials that are handled or used in unsealed forms should be confined to control the release of material and to prevent the spread of contamination. Gaseous, volatile, and fine particulate solid materials should be handled in closed or isolated systems such as fume hoods or glove boxes with controlled (possibly filtered) exhaust systems. Liquids should be handled in areas

that are easily cleaned, and with the use of appropriate means of splash control.

3. **Open areas**
   - Bench top or open work areas may be used for sealed sources, for small quantities of solid materials in a form not likely to become airborne or dispersed, and for small quantities of liquids of such low volatility as not to cause airborne contamination or toxicity problems. Trays and/or absorbent surface covers to catch and retain spilled liquids should be used on these open work surfaces and inside closed systems discussed below. Surfaces should be smooth and non-porous, to facilitate decontamination.
4. **Hoods**
   **-** Chemical-type fume hoods provide a working area with controlled inward airflow from the room to the hood exhaust system. Hoods are used for gases, for unsealed volatile licensed materials, and for processes such as evaporation that may release gases and vapors. Fume hoods provide emergency ventilation and exhaust for unplanned releases, such as accidental spills and ruptures, as well as routine exhaust of effluents. Filters may be required in the exhaust stream unless monitoring and/or calculations demonstrate that any planned or likely effluent will be in accordance with the limits found in 10 CFR 20, Appendix B.

2. **Minimum structural requirements for workplaces**
   In general the following minimum requirements are necessary for the use of radioactive materials:
   a. **Floors**
      : Floors must be covered with smooth, nonporous and easily cleaned surface such as linoleum or tile or equivalent. Work with radioisotopes will not be permitted in laboratories with unsealed concrete, clay tile or wooden floors.
   2. **Benches**
      : Benches must be composed of nonporous, easily decontaminated surfaces. Porous alberene stone or soapstone surfaces are unacceptable unless covered with an approved epoxy or strippable paint. Surfaces of high quality plastic or laminate or stainless steel are preferable. Whenever possible trays with raised edges shall be provided for all work areas involving the use of radioactive materials.
   3. **Sinks**
      : Sinks should preferably be stainless steel or seamless molded contractions. Sinks of alberene stone or soapstone should not be used.
   4. **Hoods**
      : Only laboratories using small quantities of Group 4 radionuclides will be exempt from requirements for the use of fume hoods. Hood should preferably be of seamless stainless steel, molded fiberglass or if constructed of masonite or transite, coated with strippable or epoxy paints. Hoods in which radioactive materials is to be used must be approved by the RSO. Laboratory operations involving more than low-level activity should be conducted in a properly designed and operating fume hood providing a minimum air flow of 100 linear feet per minute through the face opening of the hood.
3. **Additional room design features**
   a. **Plumbing**
      1. Sink faucets should be designed, where possible, for operation by foot, knee, or elbow rather than by hand. If not practical to install such equipment, faucets and handles must be monitored before and after use.
      2. Plumbing and ductwork should be designed to avoid radioactive contamination build-up. This build-up of contamination can create external radiation exposure hazards.
      3. A particular sink should be designated for disposal of liquid radioactive waste to the sanitary sewerage system. In some cases, depending on number of users and distance between areas of use, more than one sink may need to be designated.
   2. **Electrical**
      1. Areas of use should be well lighted to avoid spills and other accidents that could result in contamination build-up.
   3. **Air flow**
      1. Where appropriate, ventilation systems should be designed, such that, in the event of an accident, they can be shut down and isolated to contain radioactivity.
      2. If respiratory protective equipment will be used to limit inhalation of airborne licensed material, follow the provisions of 10 CFR Part 20, Subpart H.
4. **Essential furnishings**
   a. **Shielding and remote handling tools**
      1. Shielding consisting of lead or other high-density material in the form of bricks, panels, L-shields, storage containers, or other shapes may be used on bench tops, in fume hoods or in

glove boxes to reduce radiation exposure from gamma-emitting radioactive materials. Similarly, shielding of low atomic number material, such as high-density plastic, may be used to reduce exposure from high-energy beta-emitting materials. Shielded shipping containers are frequently used for continued storage after receipt of materials.
2. Remote handling tools, such as forceps or extension handles, should be used to provide distance in the handling of radioactive materials (ALARA). In addition, shielded handling devices, such as shielded syringes, can be used to protect workers from materials that cannot be handled remotely. Pipetting should be done using appropriate devices. Pipetting by mouth is strictly forbidden.
3. Observation of activities conducted behind shielding with remote tools (or with extended arms and hands, within limits consistent with permissible occupational exposures) can be accomplished using mirrors, through shielded (e.g., leaded glass) windows, through transparent plastic beta shields, or by remote video monitoring.
4. The combination of containment, shielding, and handling devices proposed for any use of radioactive materials should be appropriate to the type and quantity of materials to be used and to the type and duration of operations to be conducted.

2. **Waste**
   1. Labeled waste containers must be used. These containers will be shielded as necessary, placed near the waste-generating areas and away from areas frequently occupied by personnel. Additionally, these containers must be effectively enclosed to prevent airborne contamination from radioactive materials deposited.

5. **Workplace standards for operations with unsealed radioactive material** All operations with unsealed radioactive materials at UWW must be conducted in such a manner and in such a workplace to minimize the hazard of internal ionizing radiation. The protective measures required by the UWW HWRBS take into account the nature of the operation, the radionuclides involved, the physical and/or chemical form of the radionuclide, and the quantities that will be used. In the absence of any additional requirements set by the HWRBS, this document establishes a set of minimum workplace standards. The preceding four sections described essential features of rooms. In this section, the guidelines are combined in established combinations to establish three basic types of workplaces suitable for work involving unsealed radioactive material.
   a. **Type A - Chemical Laboratory**
      - Most low level uses of radioisotopes can be safely conducted in a normal chemical laboratory or Type A workplace, equipped and operated as follows:
      1. The ventilation shall provide at least four air changes per hour.
      2. Work surfaces for radioactive experiments shall be smooth, impermeable, and covered with absorbent paper, or stainless steel trays
      3. Areas used for work with radioactive material must be clearly marked with radiation warning tape and used only for radioactive work.
      4. All radioactive sources shall be stored in cabinets, desiccators, or designated refrigerators and freezers.
      5. Personnel shall wear lab coats and gloves while working with unsealed radioactive material.
      6. The term "Chemical" is not meant to exclude laboratories in other departments such as Physics or Biological Sciences. Instead the term is used to reflect a laboratory appropriate for the use of chemicals, as opposed to a dedicated-use "laboratory" containing only computers or musical instruments, or other such settings.

      **Example:** Upham Hall 133.
   2. **Type B - Chemical Laboratory with Fume Hood**
      - A Type B workplace is used for operations of moderate hazard levels that require the additional protection of an adequate fume hood.
      1. All the requirements for a Type A workplace.
      2. In addition to wearing lab coats and gloves, personnel must wear safety glasses when conducting complex chemical operations.
      3. Operations with quantities of radioactive material exceeding the limits for a Type A workplace shall be done in a fume hood. The hood must have an average face velocity of 125 lfm (linear feet per minute) with the sash at 80% open.
      4. During the time that Type B workplace quantities are actually in use, users must make regular radiation surveys of their laboratory.

      **Example:** Upham Hall 337.
   3. **Type C - Radioisotope Laboratory**

- A Type C workplace is required for high hazard operations. A detailed design guide for such a laboratory can be found in the American Standards Association design guide N5.2-1963. The particular details for a given laboratory must be reviewed by the HWRBS. In general, they must include the following:
    1. All the requirements for a Type B workplace.
    2. Restricted access to, and use of, the area. Because the majority of the work involves use of radioactive material, no desk space or other "dual" use of the area is permitted.
    3. Additional personnel protective garments may be required, such as shoe covers.
    4. Daily concentration monitoring by the user.
    5. Contamination of hands, shoes, and clothing shall be checked at the termination of operations.

  **Example:** Upham Hall 133A.

6. **Workplace Determination Calculations**

To verify a particular laboratory is an appropriate setting for a specific experiment, each AU/PI (with guidance of the RSO) will need to include a "workplace determination calculation" in an application to the HWRBS. This need only be completed for each novel application for radioactive material, protocol, or room use. To determine the type of workplace required for a particular operation, the relative radiotoxicity of the radioisotope, the physical and chemical form of the material, and the type of manipulations must all be considered.

Consider the following analysis to be a guideline for work with a quantity of material. If a detailed analysis of a specific experiment and laboratory reveals circumstances not covered in this guide, the UWW RSO and the director of the Office of Risk Management and Safety may increase or decrease the quantities allowed in a given workplace type.

The following equation is to be used to determine the effective quantity of a radioisotope in a given operation.

$$Q_{eff} = Q \times A \times H$$

**where $Q_{eff}$** = effective quantity in millicuries

Q = actual quantity in millicuries
A = action factor
H = hazard factor

$Q_{eff}$ is the quantity ultimately used to determine the type of workplace required for a given class of radioisotope. The classes of radioisotopes are determined by the relative radiotoxicity of the radioisotope listed in Table 5.

Q is the actual quantity of radioisotope used in the operation.

A is a factor to account for the overall probability that radioactive material may be released to the environment and subsequently inhaled or ingested. This factor involves consideration of the complexity of manipulations and the potential energy released in the operation (i.e., highly exothermic reactions).

H is a factor to account for additional hazards which exist due to the physical or chemical form of the radioactive material (i.e., nucleic acids, nucleic acid precursors, gases, fine powders, carcinogens, toxins, explosives, aerosols, etc.).

Write out the equation. Enter the actual amount (Q) of radioactive material in millicuries. Use Table 5 to identify the toxicity class for the radioactive material. Refer to Table 6 to determine the Action Factor (A). Refer to Table 7 to determine the value for the Hazard Factor (H). Calculate $Q_{eff}$.

Finally, find the intersection on Table 8 where the toxicity classification group (row) and the intended workplace (column) meet. The effective maximum quantity ($Q_{eff}$) listed in Table 8 should be equal to or less than the amount for the planned experiment. Verify that the proposed laboratory workplace is the appropriate type, or make alterations to the planned use of radioactive materials (type or form of radioactive material, amount, operation, or location).

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**B. Communication and Posting Requirements - Caution Signs and Labels** Notices, signs and procedures shall be posted in all restricted (radiation) areas as required by the U.S. Nuclear Regulatory Commission. In general, the RSO will assume the responsibility of providing the mandatory signs for posting in laboratories and other areas where radioactivity is in use. Laboratory personnel are responsible for the labeling of containers and laboratory apparatus in which radioactive materials are used in that location.

**1. Mandatory (NRC-required)**. In laboratories using radioactive materials, the following standard signs must be posted:

a. NRC Notice to Employees (NRC Form 3).
2. Radiation Emergency Procedures.
3. Notice of Federal Regulations.
4. "Radiation Caution" signs.
5. "No smoking, eating or drinking" signs.

These signs must be posted so that they can easily be read by anyone entering the area; thus, these signs should be posted on or near the door of the laboratory. In the cases where the radioactive materials use area is an area within a large laboratory, there should be signs clearly identifying and demarcating the restricted area. In the cases where the radioactive material use area is a small room within a larger room (133A Upham and 337 Upham), the signs should be posted near the entrance to the smaller room, not in the hallway, unless radioactive materials are to be used in the larger room.

**2. Lab-specific signs**. In each facility containing radioactive materials, a map of the room should be posted near the entrance. The map aids new members of the lab in learning where use is appropriate or inappropriate. Further, in the event of an emergency, the map will be valuable in identifying and describing the site to the RSO and, if necessary, to emergency personnel.

**3. Access or travel zones**. At this time, there are insufficient quantities of radioactive materials in use at UWW to necessitate the labeling of hallways as having high levels of traffic of radioactive materials.

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# Section IV

## IV. Preparatory Paperwork - Approvals Required for the Use, Purchase, and Transfer or Shipment of Radioactive Material

### A. Tracking Radioactive Materials from "Cradle to Grave"

As a licensee of the NRC, UWW must comply with federal, state and other regulations. To maintain compliance, users and anyone with potential for exposure must be trained to use radioactive materials responsibly. Specifically, we are accountable for all radioactivity from the time it arrives upon campus to the time it decays, is transferred to someone else, or is disposed. The process of tracking radioactive materials from their arrival to their departure is nicknamed "cradle to grave" management. On the following page, Figure 1 presents an overview of this model of management of radioactive materials and waste.

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### B. Obtaining permission to use radioactive materials

**Any person wishing to use radionuclides shall first obtain permission from the HWRBS, in accordance with the terms of the license held by UWW. The application submitted to the Committee shall contain the following information:**

1. Names of the faculty who will be responsible for the safe use of the radionuclides.
2. Location of use, including building and room number.
3. List of radionuclides to be used including element number and mass number, chemical and /or physical form, and maximum amount in possession at any one time.

4. A description of how the radionuclides are to be used.
5. Description of radiation safety instrumentation including the manufacturer's name and model number, the number of each type of instrument available, the type of radiation detected, the sensitivity range (mR/hr, or cpm), the window thickness in mg/cm2, and the type of use (monitoring, surveying, assaying or measuring).
6. Description of the radiation safety instrumentation calibration procedure and the frequency of calibration.
7. A description of the equipment and facilities including a floor plan of the laboratory and information on equipment used for radiation safety.
8. Description of special radiation safety procedures.
9. Statement of the radiation safety training received by the applicants.
10. Names and addresses of organizations at which the applicant may have received occupational radiation exposure.

**Following receipt of an application for radionuclide use, the HWRBS will evaluate the applicant's qualifications and the radiation safety of the proposed use. Approval is granted to those applicants who, in the Committee's judgement, demonstrate the ability to handle radioactive materials in a safe manner. Approval will generally be granted if:**

1. The applicant has had sufficient training and/or experience so as to perform the proposed work in a safe manner.
2. The work to be performed does not exceed the applicant's knowledge and ability to cope with the hazards involved.
3. The applicant meets any special medical requirement that the HWRBS may stipulate.

**The use of radioactive material shall be performed in accordance with the conditions of the submitted application that is made a part of the approval. Radioactive materials are to be used only in those facilities that have been approved by the HWRBS.**

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## C. Procedure for purchase of radionuclides

1. An application for radioactive material procurement must be made on forms furnished by the RSO. A completed requisition/purchase order must accompany the application. The requisition/purchase order must clearly indicate that radioactive material is being requisitioned.

2. Only AU/PI's may submit requests to obtain radioactive materials. AU/PI's must have been previously approved by the HWRBS to use radioactive materials.

3. All applications shall be submitted to the RSO for approval. If the application is approved, the requisition/purchase order will be marked "approved", signed by RSO, and forwarded to Accounting by the RSO. Accounting will NOT under any circumstances approve a requisition for radioactive materials unless it has been approved by the RSO.

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## D. Procedure for receiving radionuclides

1. All radionuclides, except for exempt quantities specified in 10 CFR 20.205 and radioactive material transferred directly from another licensee, shall be delivered directly to the RSO for examination and monitoring. No deliveries will be accepted after normal working hours unless prior arrangements are made with the RSO.

2. Upon receipt of a package of radionuclides, the RSO shall examine the package for physical damage. If the package is visibly damaged, the RSO shall:
    a. Monitor the exterior of package with an appropriate survey instrument and/or perform a wipe test to determine if and how much radioactive material has leaked from the container.
    2. If leakage had occurred, place package in a safe container using protective gloves and tongs. Clean up spillage following emergency procedures.
    3. Transport package to an appropriate radionuclide storage area, for storage until receipt of instruction on disposition.
    4. Notify immediately the NRC Region III Office, final delivering carrier and supplier.
    5. Attach label and caution signs on container indicating nature and degree of radiation hazard.
3. **If package is free of visible damage:**
    1. Transport the package to approved lab or storage.
    2. Wearing protective gloves, monitor the external surfaces of the package and the final source container for radioactive contamination caused by leakage of the radioactive contents. Monitoring shall be performed as soon as practicable after receipt, but no later than 3 hours after the package is received during normal working hours, or 18 hours if received after normal working hours. The external surface of the package shall first be monitored with an appropriate radiation survey instrument to determine if radiation levels are within limits specified on package label. Next, the external surfaces of the package and the final source container shall be wipe tested for removable contamination. If removable radioactive contamination in excess of 0.01 microcuries (22,000 dpm) per 100 square cm of surface is found on the package, the final carrier and the NRC Region III Office shall be notified immediately.
    3. The results of the monitoring shall be recorded and the records retained for at least 2 years.
4. If there is no leakage or contamination, the package will then be delivered to the approved user.
5. Upon receipt of radioactive material transferred from another licensee, the approved user shall be responsible for performing the necessary examination and monitoring and submitting a report to the RSO.

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## E. Procedure for transfer or shipment of radionuclides

1. Applications for transfer or shipment of radionuclides must be made on forms furnished by the RSO.
2. Applications shall be submitted to the RSO for approval before any radioactive material is transferred or shipped.
3. No radioactive material shall be transferred from one department or laboratory to another without the approval of the RSO, since approval for possession and use of such material is given only for the original working area(s) and the original authorized user(s).
4. A list of the requirements for shipping of radioactive materials is available as a supplement from the director of Risk Management.

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## F. Records of Radioactive Materials

UWW, as a licensee of the NRC, must maintain records of receipt, transfer, and disposal of licensed materials. This ensures accountability and aids in avoiding exceeding possession limits. Records must be kept as shown on Table 9

Records pertaining to receipt, transfer and disposal typically contain the following information:

1. Radionuclide and activity (in units of Becquerels or Curies), and date of measurement of byproduct material.
2. For each sealed source, the manufacturer, model number, and location. If the source is within a device, the manufacturer and model number of device containing the sealed source should also be recorded.
3. Date of transfer, name and license number of the recipient, and description of the affected radioactive material. Information should include radionuclide, activity, manufacturer's information.
4. For licensed material disposed as waste, include the radionuclide, activity, date of disposal, method of disposal (DIS, sewer, etc.), and information on environmental monitoring before and after disposal.

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# Section V

## V. Processes - Rules & Procedures for Use of Radionuclides

## A. Purposes of Radiation Control

1. Exposure to radioactive materials While radiation is a powerful tool for education and for research, its "power" is not like electricity and cannot be limited or confined by the touch of a switch. Radiation protection practices are based upon the assumption that any exposure to radiation may be harmful. Physical safeguards and behavioral practices must be in place which protect workers and the general public from unnecessary exposure and which keep exposures "As Low As Reasonably Achievable" (ALARA). This is the cornerstone of radiation protection.

   In order for the control program to succeed, all users (AU/PI and students) must become proficient in the proper use of safeguards. It is the responsibility of each user to become familiar with the content of this Manual so that she/he may select and implement those safeguards best suited to her/his particular situation. Following the policies of ALARA benefits individuals working with radioactive materials, but also includes the goal of avoiding exposure to members of the general public. This can be done by two major emphases:

   - Control the use of radioactive materials. Radioactive materials use is strictly controlled. All purchases must be approved by the RSO. Each AU/PI is allowed sufficient material to teach and or to perform research, but there are specific limits for each radioisotope and new receipts must be balanced by disposals. Workers are trained on safe use and control of radioactive materials. The RSO performs regular reviews.
   - Prevent the spread of contamination. All lab workers must be sufficiently trained in both radiation safety and general laboratory procedures:
     - to work competently,
     - to insure that accidents with radioactive material are kept to a minimum, and
     - to prevent the spread of contamination from the laboratory, thus keeping exposure to members

of the general public low, should an accident occur

Various regulatory and advisory groups for guidance have established maximum permissible limits for both internal and external exposure to ionizing radiation in the conduct of radiation safety programs. These limits are set at levels deemed sufficiently low to prevent acute radiation effects and to limit the risk of non-acute effects to an acceptable level. As used here, acceptable risk means the assumed risk, which is deemed acceptable to the individual and to society in view of the benefits derived from such activities. Much lower limits are set for the exposure of individuals who are not occupationally involved.

2. External radiation sources External exposure comes from radiation sources outside the body. Sources of external exposure are gamma rays (from I-125, I-135, Cr-51, Fe-59, Na-22, and others); X-rays (from X-ray machines, animal irradiators, X-ray diffraction instruments, and electron microscopes), and neutrons (from Cf-252, Pu-Be sources). These are all penetrating forms of radiation that may reach any tissue of the body, including highly radiosensitive proliferative regions such as blood forming tissue and reproductive organs, as well as less sensitive skin and connective tissues. Exposure is thus dependent on the type and energy of the radiation. Low energy beta particles (with Emax < 200 keV = H-3, C-14, S-35, Ni-63) do not have enough energy to travel far in air; thus they are not of major concern as external sources. Even at close range, lower energy beta particles may penetrate only a few millimeters or less into the skin, a relatively radioinsensitive tissue. Likewise, alpha particles with their large mass have very low penetrating ability and do not represent an external exposure hazard.

   The external radiation sources of concern (high-energy b particles, g-rays, x-rays, and neutrons) deposit energy and produce ionizations as they pass through matter. Anything placed between the source of radiation and the worker will absorb some of the radiation energy and reduce exposure. A shield is a material of some thickness that will stop or effectively reduce radiation to non-hazardous levels. Different radionuclides emit different types and energies of radiation. High-energy beta particles may provide a source of photons unless shielded. An example of this type of hazard is the bremstrahlung radiation produced by the interaction of high energy P-32 beta particles in high density shielding material. Low density shielding (lucite, water, glass) is preferable to lead for P-32 shielding in most cases. For gamma rays and X-rays, lead is the preferred shielding material. Although the composition and thickness of appropriate shields vary, shielding provides an effective strategy for limiting exposure to radiation.

   A second strategy for reducing exposure from external sources is by reducing the time spent in the vicinity of such sources. This is true for all gamma emitters and may be particularly important when handling large quantities of high-energy beta emitters. Most procedures require handling of radiation for only brief time periods. The time for a procedure can be further improved by doing a "dry run"; in addition to confirming the presence and placement of necessary equipment and supplies, the worker can improve their skill and decrease the time performing the procedure.

   The third strategy for limiting exposure is to increase the distance from a source. The Inverse Square Law describes the relationship between distance and intensity: the intensity decreases by a factor that is inversely proportional to the square of the distance. For example, by doubling the distance between the worker and the radiation source, the radiation intensity decreases by a factor of four. Increasing distance from a source is a very effective way of decreasing exposure. Do not stand near unshielded sources unless actually working with them. If you are not handling a source, move at least 2 meters away from it. If you must work with high activity (i.e., > 37 MBq [1 mCi]) sources, work at arm's length, use tongs or long- handled tools to increase the distance to your hands and to your whole body.

   > **The proper use of any one or combination of these strategies - time, distance and shielding - can significantly reduce unnecessary exposures and ensure the safety of personnel by keeping exposures as low as reasonably achievable.**

3. Internal Radiation Sources Internal exposure will occur if radioactivity is taken into the body by inhalation, ingestion, or absorption through intact skin, or injury. Its presence within the body enables the material to irradiate cells tissues and organs normally protected by their depth. Any radionuclide taken into the body will irradiate tissue intimately until it is lost through decay and normal elimination processes. The critical organ or tissue is the part receiving exposure that results in the greatest damage.

   During the initial period following ingestion of radioactive materials, that portion not absorbed will irradiate the walls of the gastrointestinal (GI) tract; the epithelium of the GI tract may thus be considered the critical organ. Following absorption of radioactive material from the GI tract, radionuclides may be deposited in other organs (i.e., strontium in the bone, iodine in the thyroid, etc.) resulting in radiation doses to these organs. For chronic exposures the overall exposure results from nuclides in the GI tract as well as from those deposited in other organs.

Absorption of radioactive materials, through open wounds or even through intact skin, is a potential hazard when more than tracer quantities of radionuclides are handled. Retention of such materials in the skin itself may be an external hazard if penetrating radiation is emitted by the radionuclide. Iodine and tritium (H-3) may be easily absorbed through the skin.

The behavior of tritiated compounds deserves special attention. The external hazard from the use of tritium is generally considered insignificant due to the low energy of the beta particle emission and the unlikely possibility it will penetrate the dead skin layers. However, under saturated conditions, the absorption of tritiated water through the skin is equal to the absorption by inhalation. Tritium ingested as tritiated water mixes with the total body water and is comparatively rapidly excreted. If ingested as tritiated thymidine, however, some it becomes incorporated in the cell nucleus into the structure of DNA. In this case, the estimated dose to the nucleus is 1.1 rads/disintegration. The genetic risk is extremely high when ingested as tritiated thymidine compared to normal biological hazard of tritiated water.

The control of an internal exposure caused by the entry of radioisotopes into the body requires the proper use of equipment, good housekeeping, good personal habits and common sense. Procedures seeking to eliminate entry through inhalation or ingestion of materials are required in much the same manner as those required when working with pathogenic bacteria or viral organisms. Control of ventilation, reduction in the generation of mists, aerosols or fumes and elimination of direct ingestion through hand to mouth transfer are to be considered carefully. Specific procedures will be needed for each situation but certain guides should be followed.

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## B. Use of Radioactive Materials in Laboratories

1. **General issues**
   There are six essential elements in an effective radiation safety program. The HWRBS and RSO provide organization, guidance and direction to the entire program. Work area design provides facilities that physically limit potential for problems. Bookkeeping on all radioactive materials enables them to be tracked throughout their stay on campus. The RSO performs regular audits and inspections. Emergency procedures

have been developed and are periodically practiced.

The sixth element is that of administrative procedures addressing personnel and materials. Personnel shall have training prior to working with radioactive materials, in a manner appropriate to the depth of work to be done. Users will be provided with personal protective equipment and instructed on its effective use. Radiation will be monitored. Radioactive materials are under tight control, both in terms of volume and security at all times. Finally, waste shall be disposed via appropriate routes.

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2. **Laboratory requirements**
The physical requirements for laboratories using radioactive material depend upon the type and quantity of activity, the complexity of the laboratory operations and the relative toxicity of the various radionuclides used (see Tables 5, 6, 7, and 8). A standard laboratory will generally require specific alteration to meet requirements for use of radioactive materials. Specific requirements will vary according to the intended use, the isotope, etc. It is the responsibility of the RSO to provide evaluations and assistance to each user in determining specific requirements. Detailed descriptions can be found in Section III (Facility Design).

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3. **Personnel requirements**
   To help increase effectiveness and productivity and decrease problems, individuals working with radioactive materials must participate actively in safety measures. They must therefore have training in safe laboratory practices in general and in radiation safety in particular. Further, users must be provided with (and use) personal protective equipment and personnel monitoring methods, if appropriate.

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   a. **Personnel training in radiation safety**
      1. The RSO shall direct and monitor the instruction of all individuals working in radiation (restricted) areas. Training topics will include:
         a. a. Health protection problems associated with exposure to sources of radiation.
         2. Precautions and procedures to minimize exposure.
         3. Purpose and functions of protective devices employed.
         4. Rules and procedures mandated by UWW, NRC, and Wisconsin. This will include regulations and license provisions for the protection of personnel from exposures to radiation or radioactive materials. Users shall be further instructed to observe all such applicable provisions to the extent within the worker's control.
         5. Appropriate responses in emergency situations that may involve exposure to radiation or radioactive materials.
         6. Radiation exposure reports which workers may request.
         7. User's responsibility to report to the RSO any condition which may lead to or cause a violation of the university's rules or the regulations of the U.S. Nuclear regulatory Commission or the state of Wisconsin, or unnecessary exposure to radiation or to radioactive materials.
         8. Other topics as listed below.
      2. The extent of the above instructions shall be commensurate with potential radiological health protection problems in the restricted (radiation) area.
      3. Faculty, under the direction of the RSO, may provide required training for students. This is appropriate for select settings when radioactive materials are being used for demonstration purposes only (classroom use). This is generally inadequate for students who will be working with radioactive materials in independent study (research) projects.

      Training content will be targeted to the particular audience and their needs. Thus training for an AU/PI needs to be very detailed, including information on record keeping. Authorized users must have at least 20 hours of formal training and 20 hours of experience. Training for students who will work on a research project must be more extensive than that for students who will be observing a demonstration using radioactive materials. Ancillary personnel need to be informed of the safeguards in place, and of their right to ask for a demonstration that materials are not contaminated, but they need not have detailed training in nuclear decay. Ancillary personnel is defined as supporting staff: technicians who work in the department but who do not specifically work with radioactivity as part of their responsibilities, housekeeping staff, plumbers, etc. In addition, individuals from off-campus (outside contractors, emergency response personnel) who will be working in areas with radiation may also need training. While extensive formal training is not necessary for ancillary personnel or individuals from outside the University community, these individuals should receive some type of orientation to prepare them to respond effectively in case of an emergency or to aid them in performance of their normal duties.

      Depending on intended breadth of use, a user needs training on topics including:

      - characteristics of ionizing radiation
        - modes of exposure
        - dose equivalent estimates
        - protective measures: time distance shielding
        - radiation effects: acute, chronic
        - contamination control: work place design, personal protective equipment

- radiation monitoring program
- warning signs, alarms, controls
- emergency procedures
- responsibilities: RSO, AU/PI, students, HWRBS, Administration

Training experiences need to be documented. The RSO must file records upon completion of the training session(s). The RSO will submit a memo, describing the training session(s), to be placed in the file of the trainee. One copy of the memo will be placed into the RSO's files and one copy sent to the Office of Risk Management. Additional materials filed in the latter two administrative offices will include the following: a summary of program contents, a signature sheet, copies of any handouts distributed at the session, and a copy of the trainer's credentials.

2. **Personal Protective Equipment (PPE)**

In terms of protection against unnecessary exposure to any kind of radiation, engineering controls are the first line of defense. To minimize external exposures, users also need to use good work practices: time, distance and shielding. In addition, good housekeeping (regular cleaning) of the work area will limit or eliminate unplanned exposures.

To minimize internal exposure from radioactive materials, the user is best protected by good laboratory work skills. Ingestion of radioactive materials can be blocked by prohibition of eating or drinking in the work area, and encouraging good hygiene practices. Puncture wounds are avoided by disposing of sharps into rigid containers.

Use of Personal Protective Equipment (PPE) provides another method to block entry of radioactive materials into the body. Personal protective equipment is special clothing or equipment worn by the user for protection against radiation and other hazards. A respirator is a facemask that allows air to pass but contains filters to trap volatile radioactive materials, thus avoiding inhalation. Dermal absorption can be avoided by wearing coverings over parts of the body with potential for exposure. This includes hand protection (lightweight disposable gloves; or heavyweight gloves); body or clothing protection (lab coats, aprons); and eye protection (safety glasses, face shields).

Each PPE item acts as an extra barrier and it should be easily removable. In case of contamination, removing a lab coat is much easier than removing a shirt. Some PPEs are disposable (gloves); others can be stored for extended periods of time while radioactive decay eliminates the problem.

If an item of clothing becomes contaminated, it must be removed without spreading the contamination to other locations. Thus, if a shirt becomes contaminated, you need to avoid contact of its outer surface with your skin, other clothing, and other objects in the work area. In this example, first verify that your gloves are not contaminated, or change to a fresh pair. As you pull the shirt upward, pull the contaminated area away from your face. Rolling the shirt so the contaminated area is inside the roll is also helpful. If the contamination penetrated the covering, check you body for cuts or scrapes near that site.

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4. **Personnel Monitoring**
   Devices appropriate to the type and level of radiation used must be available and used by all personnel involved with ionizing radiation. Federal and State regulations require the use of such equipment by each individual who enters a restricted (radiation) area under such circumstances that he is likely to receive a dose in any calendar quarter in excess of 25 percent of the quarterly whole body Maximum Permissible Dose (M.P.D.) and 5 percent of the quarterly M.P.D. in the case of individuals under 18 years of age, based on a quarterly whole body M.P.D. of 1.25 rems. {See 20CFR20.101, Permissible Doses, Levels, and Concentrations.} At this time, no users are working with these levels of radioactivity. Should conditions changes, the following will apply:

   1. Except as provided in part 2 below, film badges must be worn by faculty, staff and students in the following instances:
      a. When working with 1 MEV or greater beta emitters.
      2. When working with all gamma emitters.
      3. When working with neutron sources or neutron generating devices.
      4. When working with X-ray producing devices.
   2. Film badges need not be worn in cases where it has been definitely established by the RSO that exposures will not exceed limits. This will depend upon the intensity and energy of the radiation and the working conditions involved.
   3. Pocket dosimeters should also be worn by personnel in instances where exposures in excess of 25 percent of the daily M.P.D. are anticipated. Based on a quarterly whole body M.P.D. of 1.25 rems, the "daily" M.P.D. may be assumed to be 20 millirems.

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5. **Bioassay Requirements**
   Bioassays may be required if individuals work with certain unsealed radioisotopes. The types and activity levels that would mandate such testing are specified in Table 10. "Working with" these radioisotopes refers to amounts used at any one time or total amounts used during a 3-month period.
   1. Bioassays that shall be performed by the approved user and reported to the RSO include:
      a. Baseline bioassay prior to beginning work with the specific radioisotope.
      2. Routine bioassays at a frequency as specified in this section.
      3. Emergency bioassays as soon as possible after any incident.
      4. Postoperational bioassay within 2 weeks of the last possible exposure to the specified

radioisotope.

2. The frequency of the bioassays shall be as follows:
   a. Initial routine bioassays within 24 to 48 hours after beginning work with the specified radioisotope.
   2. Every two weeks thereafter as long as individuals are working with or exposed to the specified unsealed radioisotope.
3. Bioassays shall consist of urinalysis in the case of tritium and thyroid burden test in the case of radioiodine. Whenever the urinary excretion rates exceed 5 mCi/liter or the thyroid burden exceeds 0.04 mCi of I-125 or 0.12 mCi of I-131, the results shall be reported immediately to the RSO who shall take the following action:
   a. Exclude the individual from further exposure until the source is discovered and corrected.
   2. Survey the operations to determine the cause(s) of exposure and evaluate potential for further large exposure.
   3. Take corrective actions that will eliminate or lower the potential for further exposures.
   4. Perform a repeat bioassay within one week of the previous test and evaluate within 24 hours.
   5. The RSO will make reports and notifications as required by 20.405, 20.408, and 20.409 of 10CFR part 20.
4. If the urinary excretion rates exceed 50mCi/liter of I-125 or thyroid burden exceeds 0.05 mCi of I-125 or 0.14 mCi of I-131, the following actions shall be taken by the RSO:
   a. Carry out all steps described in section d (1-5) above.
   2. Refer the case to appropriate medical consultation for recommendations regarding therapeutic procedures that may be carried out to accelerate removal of the radioisotope from the body.
   3. Carry out repeated measurements at approximately 1-week intervals at least until test results are below the limits contained in section II.A.4.d. above. If there is a possibility of longer-term compartments containing a radioisotope that require evaluation, continue measurements as long as necessary to ensure that appreciable exposures to these other compartments do not go undetected.
5. The results of all bioassays shall be reported to the RSO as soon as possible and no later than three days after the results are obtained.

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4. **Rules and procedures of laboratory practice involving operations with radioactive materials**

Careful planning and the exercise of good judgment can minimize both external and internal radiation exposures. The following guides for dealing with radioactive materials and sources should be implemented where applicable. Each AU/PI should use these guides and require all those under their supervision to do the same.

- Plan work ahead. Whenever possible do a "dry run" - a practice trial using non-radioactive materials helps you test the set-up and the procedure, and helps identify missing items.
- Personal Protective Equipment, particularly clothing, should be worn when working with radioactive materials. A lab coat should be buttoned while you are working. It should not be worn out of the laboratory area. It should be monitored periodically, especially before laundering. If necessary, contaminated clothing shall be decontaminated or disposed if contamination significantly exceeds background. Never store laboratory protective clothing with street clothes.
- No mouth pipetting of radioactive materials is allowed. Use rubber bulbs, syringes, pipettors or other mechanical devices when transferring radioactive materials.
- Label all radioactive materials. Labels should include radionuclide, amount, date and your initials.
- Radioactive materials should not be left unattended on top of a laboratory workbench.
- Store and transport radioactive material in liquid form in double containers.
- Dispose of waste as it is generated. Place it into the appropriate container ("hot" vs. "cold", etc.).
- Clean up spills as soon as possible - immediately, at the fiHWRBS break in the protocol, or upon completion of the experiment but BEFORE leaving the work area.
- Contaminated equipment or work surface contamination must be labeled if it cannot be removed.
- Containers that previously held radioactive materials must be monitored before disposal to insure they are not contaminated. Remove or obliterate radiation labels before disposal of a clean container.
- Make sure there is adequate ventilation where you are working. If you are working with a volatile material, it should be vented away from you; the best method for this is use of a fume hood.
- Keep pathways to exits clear. Do not obstruct access to emergency equipment and electrical controls.
- Telephones, doorknobs and other "clean" items should not be handled with contaminated gloves or hands. These items should be monitored regularly to verify they retain their "clean" status. If found to have surface contamination, these items must be decontaminated immediately. The location and operation of emergency equipment should be familiar to all laboratory workers.
- Keep the laboratory neat and clean. Equipment or material not being used should be stored in a place away from the work area.
- Eating or drinking is prohibited in dedicated radionuclide laboratories. If the lab is multipurpose, these activities shall be prohibited in the areas in which radionuclide work occurs. Eating, drinking, chewing gum, etc. shall not be performed while handling radioactive material.
- Food containers are not permitted in the laboratory or near work areas. Refrigerators must be dedicated to storage of food OR of radioactive materials.
- Flammable liquids in excess of one gallon are not permitted in areas where radioactive materials are used or stored unless they are contained in approved safety cans. Flammable liquids should only be used in well-ventilated areas.
- Pressurized bottles or tanks must be properly secured.
- Caution and other warning signs shall be posted and shall NOT be removed without proper authority.
- Emergency procedures must be posted in the laboratory. All workers in the area, whether or not they work with radioactive materials, must know what to do in case of an emergency. The procedures should contain, at minimum, the names and telephone numbers of individuals to contact in the event of an emergency (AU/PI and RSO).
- All incidents or injuries, no matter how minor, must be reported to the RSO if radioactive materials are involved. The RSO will then handle any further reporting as necessary.

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## C. Laboratory monitoring and inspections

Radiation surveys are used to detect and evaluate contamination of facilities, equipment, personnel, and areas (both restricted and unrestricted). In particular, personnel participating in the use, transfer or disposal of licensed materials should be active in monitoring their work. All laboratories in which radioactive materials are used shall be routinely surveyed. Surveys shall be performed to determine both radiation levels and removable contamination levels. Surveys are also used to plan non-radioactive work in areas where licensed materials exist. Surveys are also conducted by the RSO to evaluate doses to workers and to individual members of the public.

1. **Radiation levels**
   Laboratories shall be monitored with a radiation survey meter sufficiently sensitive to detect 0.1 mR/hr. Radiation levels should be kept as low as is practical (0.25 mR/hr) but in no case should they exceed 2.5 mR/hr except under controlled circumstances for short time periods (10 minutes or less). Radiation levels in excess of 2.5 mR/hr that are detected in a survey shall require corrective steps to be taken to reduce the radiation to the acceptable limit.
2. **Contamination levels**
   A series of wipe tests shall be taken in all areas where radioactive materials are handled in unsealed form. Contamination levels shall be kept as low as is practical and any count that exceeds the minimum detectable activity above background should be considered as an indication of contamination. Cleanup of the contamination must be made if the wipe test result exceeds 100 cpm above the minimum detectable activity.
3. **Frequency of surveys**
   The approved user shall conduct an appropriate survey of the work areas at the end of each day in which radioactive materials are used. In laboratories using radioactive materials in quantities less than those stated in Appendix C of 10 CFR Part 20, the approved user need only perform a survey once a month. Determination of survey frequency is outlined below. The RSO shall conduct both radiation levels and removable contamination surveys on a regular basis.
4. **Leak testing sealed sources**
   Sealed sources containing radioactive substances over 100 microcuries of beta and/or gamma emitting material or over 10 microcuries of alpha emitting materials shall be leak tested at least twice a year by the RSO. Any detectable leakage over 0.005 microcuries must be reported to the NRC within five days of the test. Any source found to be defective shall be immediately removed from use, decontaminated and repaired, or properly disposed of in accordance with NRC regulations. The approved user shall immediately report any suspected leakage to the RSO.

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# Section VI

## VI. Products & Perversity - Management of Radioactive Samples & Waste

### A. Radioactive samples

1. **Storage - short-term and long-term**
    a. a. Radioisotope laboratories and storage areas (rooms, cabinets, safes, etc.) must be locked at all times when not in actual use to prevent theft and unauthorized use of radioactive materials.
    2. Radioactive materials stored in occupied areas shall be shielded in accordance with ALARA. The radiation level should be less than 200 mR/hr at accessible surfaces and less than 10 mR/hr at one meter from the source. This is appropriate if the normal operating distance to frequently occupied areas is such that no one is likely to exceed 10% of the permissible radiation doses (NRC regulations) or 100 mrem in a single month.
    3. Unbreakable containers are recommended for storage of radioactive liquids. Glass bottles and other breakable containers used for storage must be kept in non-breakable, leak-proof containers or trays capable of containing the entire volume of liquid waste stored therein.
    4. Radioactive gases and volatile forms of radioisotopes should be stored in a well-ventilated area, preferably in a hood or ventilated cabinet, but not in a routine work area.
    5. All active samples including calibration sources regardless of strength should be clearly labeled giving accurate information about the contents as well as the name of the AU/PI responsible for the sample. They must also carry the words "Caution Radioactive Materials". The RSO reserves the right to take possession (confiscate) unlabeled sources.
    6. All containers holding radioactive materials must be clearly labeled as such, and include the radioisotope on the label.

    **Basic Chemical Storage Procedures:**
    All radioactive chemicals should be stored following accepted safe handling procedures used for all chemicals, including those listed on this page. Chemicals should not just be stored. The stocks and inventory of laboratory chemicals need to be actively managed. This will include knowing amounts on hand, as well as separating incompatible compounds. Chemicals must be stored safely - know their characteristic hazards, then store them accordingly. Check the MSDS (Material Safety Data Sheet) for hazard information.

    Store your chemicals in a safe place. Don't use a fume hood for routine storage; keep it clear for work. For storage of volatile and odorous chemicals, use a ventilated cabinet. Use sturdy shelving with space for every container. Install small vertical barriers on the front edges of shelves to avoid having items slip off. Don't stack containers on top of other containers. Don't store liquids above solids. To avoid the risks of lifting and reaching, keep large and heavy items on lower shelves. Keep containers off open floor space, safe from an accidental kick. Use plastic trays for secondary containment to contain liquid spills. Avoid storing chemicals on shelves more than six feet above the floor. Do not store liquids above eye level. Nothing may be stored within 18 inches of a fire sprinkler head on the ceiling.

    Keep incompatible chemicals separate. Label all chemical containers. If you make solutions, synthesize products or transfer chemicals to another container, make sure all containers are labeled. Each chemical container in your laboratory should be clearly labeled with the following: chemical name, principal hazard (e.g., carcinogen, irritant, corrosive, etc.), date prepared, opened or received; initials of person completing the label. Other useful information on labels is the quantity contained and a date when disposal should be considered.

    All chemical containers must be labeled to prevent the hazards and disposal problems of unknown chemicals. However, labeling small vials with complete chemical names can be a difficult and tedious task. To make this job easier, use these tips. Label the entire group. If you have a rack with vials that hold various fractions from a column, label the entire rack with a description of what is contained in the individual vials. Give the containers numbers that are referenced in your laboratory notebook or other accessible location.

For larger stocks, devise an inventory system. The benefits of a laboratory chemical inventory system are that it prevents purchase of duplicates, it helps you monitor chemicals that degrade with age (e.g., ethers, gas cylinders). One simple method involves saving invoices. Monitor chemical use by keeping track of empty bottles.

Review the chemical inventory. On an annual basis, check the integrity of containers and labels. Dispose of unwanted, degraded or discolored chemicals. If you no longer need the chemical, offer it to the department or to someone else.

2. **Transportation**
**-** Transporting Radioactive Materials outside the Laboratory

a. Spills of radioactivity in areas such as corridors, stairs, and sidewalks are generally more serious than similar spills in laboratories because of the difficulty in controlling access to the contaminated area (high volume traffic). Therefore, extra precautions (i.e., double containers or special packing) are necessary when transporting radioactive material from one laboratory or storage room to another.
2. The outer container in which radioactive material is transported should be sealed and should be of unbreakable material. When the nature of the work requires frequent and routine transporting of radioactivity between laboratories and storage areas, it is strongly suggested that special equipment (designed for maximum safety and ease of handling) be used. A portable cooler will aid in avoiding spills.
3. When a radioactive liquid is transported in a breakable container, it must be surrounded by enough absorbent material to readily soak up all the radioactive liquid.
4. A warning sign or label shall be attached to the outside of the container if a quantity of radioactive material greater than 1 mCi is being transported or if the radiation level at any accessible surface of the container is greater than 5 mR/hr gamma equivalent. The sign shall carry the words "Caution Radioactive Material" readily legible at the distance of 5 feet.
5. A remote-handling device shall be used in carrying a container of radioactive material whose surface radiation is greater than 200 mR/hr. The device shall be constructed so as to provide enough distance or shielding to reduce the radiation level to less than 200mR/hr at the operator's position. Ease of handling and sureness of operation shall be prime considerations in the design of such devices so as to reduce time of exposure. Crucible tongs are neither sure nor quick.
6. To lessen the chance of mishaps and to reduce random exposure to members of the general population, movement of radioactivity should be restricted to periods when traffic in corridors and on stairs is light. Make transit time short. Avoid unnecessary stops along the way. Never leave radioactivity unattended in any place but a locked storage area. Also do not store radioactivity anywhere but in authorized radiation laboratories and storage areas.
7. Check the container for contamination after removal of the source. This will not only prevent re-use of contaminated containers but will serve as a check for sources with serious leaks.
8. If a spill should occur outside the laboratory, do not leave the area unattended unless it is necessary to render immediate emergency attention to personnel involved in a spill. Post a guard and restrict access to the contaminated area until such time as procedures outlined under "Emergencies" can be complied with.
9. Transportation off-campus must comply with DOT (Department of Transportation) regulations. Consult with the RSO for details and approval.

Chemicals are less hazardous when left on a shelf in their containers. Only when a chemical is moved is there a risk of a container breaking and an uncontrolled release occurring. Choose risks wisely to achieve maximal gains with minimal risks. Whether you are transporting chemicals across the lab or across the state, take precautions.

Use secondary containment. No matter how careful you are, containers can drop and bottles can break. Use a tray or a bucket to carry chemicals in transit and contain these possible accidents. Good secondary containment can mean the difference between a small inconvenience and a major building evacuation. Check a laboratory safety catalog to find other secondary containment equipment to suit your needs.

Use additional precautions when using vehicles. The transportation of chemicals in vehicles on public roads presents additional safety and legal problems. A container of flammable solvent or toxic material ruptured in a road accident drastically increases the risk to your health and makes rescue difficult. Chemicals should never be transported in the passenger compartment of a vehicle. The Department of Transportation (DOT) and the Department of Natural

Resources (DNR) regulate the transportation of hazardous materials on public roads. Depending on the type and quantity of material being transported, you may be required by law to have a special driver's license, carry proper shipping papers and use specified packaging. If you must transport hazardous chemicals on public roads, check with the RSO or the Risk Management Office first to obtain guidance on how to do it safely. A special supplement on DOT regulations is available from the director of Risk Management.

When working with radioactive materials in the laboratory setting, the user is working in a controlled environment, with controlled access and familiar surroundings; entry into the area is limited to knowledgeable individuals. When radioactive materials are transported in public, additional rules and regulations from the Department of Transportation (DOT) apply. The intent of these restrictions is to protect members of the general public, who are not radiation workers, from radiation exposure that could result from a transport accident.

Any worker involved in hazardous material packaging or transport must receive initial training, as well as refresher training every three years. At UWW, this applies to an AU/PI transporting large quantities or high activity levels of radioactive material to and from other campuses (e.g., UW-Madison). Each AU/PI is responsible for meeting the training requirement. Further, transportation shall only be undertaken by an AU/PI and not be performed by students except with the express written permission of the RSO.

Contact the RSO prior to transporting radioactive materials off-campus. In collaboration with the RSO, the AU/PI will need to develop and write a transportation plan. The plan must include sufficient details to insure the carrier is in compliance with all pertinent DOT and DNR regulations. Hazardous materials regulations cover four areas: hazardous materials designation and classification, hazard communication standard and training, packaging requirements, and operational rules.

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## B. Radioactive Waste

1. **General considerations**
    a. Basic concepts In support of the philosophy of providing a safe and supportive workplace, UWW Radiation Safety Program supports the following three concepts:
        - Waste should be managed.
        2. ü Waste should be treated to reduce or eliminate hazard.
        3. Waste should be minimized.
    2. Disposal destinations: local, commercial and government-sponsored disposal With the finite amount of space in the building, we are unable to retain all waste materials. Removing waste from the building requires an appropriate site for disposal. The only waste that may enter the local waste "streams" are cold waste (liquids or solids), or very low activity level liquid waste (when diluted with appropriate volume of running water).

Otherwise, waste must be removed from campus. The transportation and disposal of other waste by commercial disposal companies incurs costly fees. Each AU/PI is responsible for including budget resources for handling and disposal of waste, as well as decontamination supplies, for radiation that individual brings onto campus.

Besides the cost, there is potentially a greater problem - the decreasing availability of such sites. To dispose of solid radioactive wastes, users must ship radioactive materials to low-level radioactive waste disposal sites around the U.S. where they are subsequently buried. Since the availability of these sites is limited by technological, political and social factors, members of the UWW community cannot assume that these disposal sites will be available. Consequently, all radioisotope users are asked to make a conscious effort to MINIMIZE the volume of radioactive wastes generated in their laboratories.

Periodically, the government HAS sponsored removal of radioisotopes, particularly those dating to the beginnings of the Cold War era. Be aware that most of the UWW radioisotopes dating from that time have ALREADY left campus. This is not a regular means of disposal; it may not occur again. Also, when the government has "sponsored" waste removal in the past, it has mandated a payment (in the thousands of dollars) for transportation.

The RSO reserves the right to refuse to accept any materials. This is most likely to happen if the materials have been improperly prepared or packaged. If the RSO feels that the movement of the materials would pose an unacceptable hazard to UWW population or to the general public, the RSO may defer acceptance to a safer time

2. **Specific guidelines**
   a. Except as specifically and directly authorized by the RSO, NO radioactive materials shall be disposed of directly into the sanitary sewage system, into the atmosphere, or into ordinary (cold) trash baskets.
   2. When handling or transferring radioactive waste, wear a laboratory coat and disposable gloves, and other PPE as necessary (eye protection, mask, etc.).
   3. The AU/PI for each laboratory must ensure, prior to purchase or receipt of any radioactive materials, that a method for the disposal of the materials either presently exists or can be worked out to the satisfaction of the HWRBS.
   4. The AU/PI must include budget resources for disposal of radioactive materials at completion of work. Include this in grant proposals; do not expect your department or the university to cover this expense.
   5. Regardless of its contents, label each radioactive waste container with a "Caution Radioactive Materials" label, sticker or tag furnished by the RSO. Record all necessary information regarding the waste and its source on the tag.
   6. Store radioactive waste containers as close to the work area as possible to minimize the probability of spillage during transfer of the waste to the containers.
   7. Do not store waste containers in the hallways, stairwells or other uncontrolled areas.
   8. Cover radioactive waste containers when not in use. (Put a lid on it.)
   9. In cases where volatile materials are anticipated, plan to trap such materials. Any accidental release of radioactive material into the environment must be reported immediately to the RSO.
   10. Use "Decay-In-Storage" for each radioactive material with a half-life less than 120 days.
   11. Segregate wastes based on their method of disposal, chemical/physical form, and half-life. It is much easier to remove several small bottles with known contents than to remove one large but fearsome bottle of "mixed waste".
   12. Inactivate radioactive wastes containing carcinogens, biohazards, or very hazardous chemicals, if possible, and package them in such a way that they present minimal hazards to people who handle the wastes after you.
   13. The AU/PI must complete records of the disposal of ALL radioactive wastes, including decayed-in-storage wastes and exempt quantities of hydrogen-3 and carbon-14. Each AU/PI must maintain accurate records of the types, quantities, and forms of radioisotopes that are placed in the radioactive waste released from her/his laboratory. Records kept by the AU/PI may be based on either calculations or measurements. Failure to do so may result in loss of AU/PI status.
   14. Deface or remove all radioactivity labels from containers and packages prior to disposal in in-house "cold" waste. If waste is compacted, all labels that are visible in the compacted mass must be defaced or removed.
   15. Do not mix non-radioactive waste, such as leftover reagents, boxes and packaging material with radioactive waste.
   16. Occasionally monitor all procedures to ensure that radioactive waste is not created unnecessarily. Review all

new procedures to ensure that waste is handled in a manner consistent with established procedures.

17. In all cases, consider the entire impact of various available disposal routes. Consider occupational and public exposure to radiation, other hazards associated with the material and routes of disposal (e.g., toxicity, carcinogenicity, pathogenicity, and flammability), and cost.
18. Waste management programs should include waste handling procedures for the users within their laboratories or assigned areas, and for waste handlers who may collect waste from areas of use to bring to the storage area for eventual disposal.
19. Daily cleaning of restricted areas must be performed by AU/PI's; the housekeeping staff is not authorized to enter these areas for daily maintenance.
20. Risk Management will provide basic training for housekeeping staff to avoid the possibility of unauthorized disposal or exposure of these individuals to radioactive materials or to radiation. The RSO will participate if advanced training is appropriate.

3. **Disposal by "Decay-in-Storage" (DIS)**
    a. Only short-lived waste (half-life of less than or equal to 120 days) may be disposed of by DIS.
    2. Short-lived waste should be segregated from long-lived waste (half-life greater than 120 days) at the source.
    3. Waste must be stored in suitable, well-marked containers, and the containers must provide adequate shielding.
    4. Liquid and solid wastes must be stored separately.
    5. When the container is full, it should be sealed. The sealed container should be identified with a label affixed or attached to it.
    6. The identification label must include the date when the container was sealed, the longest-lived radioisotope in the container, date when ten half-lives of the longest-lived radioisotope will have transpired, and the initials of the individual who sealed the container. The container may be transferred to the DIS area.
    7. The contents of the container must be allowed to decay for at least 10 half-lives of the longest-lived radioisotope in the container.
    8. Prior to disposal as ordinary trash, each container must be monitored as follows:
        1. Check the radiation detection survey meter for proper operation,
        2. Survey the contents of each container in a low background area.
        3. Remove any shielding from around the container.
        4. Monitor all surfaces of the container.
        5. Discard the contents as ordinary trash only if the surveys of the contents indicate no residual radioactivity, i.e., surface readings are indistinguishable from background.
        6. If the surveys indicate residual radioactivity, return the container to the DIS area and contact the RSO for further instructions.
        7. If the surveys indicate no residual radioactivity, record the date when the container was sealed, the disposal date, type of waste (used or unused material, gloves, etc.), survey instrument used, and the initials of the individual performing surveys and disposing of the waste.
4. **Solid waste**

    Solid radioactive waste can be broken down into two categories: waste that contains radioisotopes with half-lives of greater than 120 days, and waste than contains radioisotopes with half-lives of less than 120 days.

    Waste containing radioisotopes with half-lives of less than 120 days are allowed to decay before disposal. Waste containing radioisotopes with half-lives of more than 120 days are either stored or incinerated.

    a. Special waste containers for disposal of dry contaminated wastes must be available in all laboratories using radioactive material. The containers shall be lined with heavyweight plastic bags and must be conspicuously labeled with radioactive material caution signs.
    2. Every solid radioactive waste container shall be marked with a "Caution Radioactive Materials" sign and labeled with any other labels which the RSO or HWRBS deems necessary.
    3. NO LIQUIDS may be disposed of in the solid waste.
    4. Solid radioactive waste should be segregated into three categories as follows:
        1. Glass and plastic items which cannot be easily decontaminated,
        2. Paper waste, and
        3. Short-lived waste to be held for decay. (This waste may contain all three mixed together.)
    5. Dry waste contaminated with radioactive material whose half-lives are less than 120 days shall be held for at least 10 half lives. By holding these wastes for decay until the nominal radioactivity levels have become indistinguishable from background levels, they can be disposed of as non-radioactive trash, at no cost to you.

Follow these procedures prescribed by the RSO:

1. Check the container for residual radioactivity.
2. A monitor with a standard end-window type Geiger counter may be used to monitor for beta and gamma emitters. This method cannot be applied whenever tritium or any alpha emitters might be present in the waste; the latter must be checked using a gamma or scintillation counter.
3. IF there is still detectable radiation, continue to store for at least 2 additional half-lives.
4. IF NO detectable radioactivity, remove or obliterate all "Radioactive Materials" labels.
5. Place objects into a regular trash bag and take it to the dumpster on the loading dock.
6. Record disposal in your records.

6. Dry waste contaminated with radioactive materials whose half-lives are greater than 120 days shall be sealed in a heavyweight plastic bag or its equivalent. The bag must be properly labeled with a completed Radioactive Waste tag. The bag should then be placed in a rigid container, such as a cardboard box.
    1. Read the UWW RSM for details and guidelines governing management of radioactive waste.
    2. The AU/PI's must provide their own disposal containers and bags. The RSO and the Risk Management Office mandates that waste be bagged in bags at least 4 mils thick.
    3. Contact the RSO to request Radioactive Waste Contents tags.
    4. Check the surface of bags for removable contamination on the outside of the bag.
        a. Moisten a piece of filter paper or a cotton swab with water or alcohol.
        2. Wipe an area of approximately 100 square centimeters per swipe.
        3. If the bag contains tritium (H-3), your swipes must be counted by liquid scintillation counting. If the bag contains other beta particle emitters, it should be sufficient to monitor the swipe with a standard end-window type Geiger counter. For gamma emitters, count the swipe with either a NaI probe or a gamma counter.
    5. Prepare waste for pickup and complete Radioactive Waste Contents tag(s). Each bag of dry waste should have a tag attached to it.
    6. Call the RSO (Office of Risk Management) to confirm pickup.
    7. Record the disposal in your records.
7. All radioisotope users are asked to make a conscious effort to MINIMIZE the volume of radioactive wastes generated in their laboratories.
8. The AU/PI must establish secure and proper storage for radioactive wastes generated in her/his laboratory.
9. The Risk Management head will only provide the storage space for materials, which contain large quantities of radioisotopes, or for wastes that contain material that is in a highly dispersible or otherwise unusually hazardous form.

5. **Liquid waste - general issues and guidelines**

Liquid radioactive waste can come in two forms, organic (less than 10% water content) and aqueous. Aqueous waste will NOT be collected for disposal by Risk Management, and should be stored for decay. Organic waste will be collected for disposal. Here at UWW, the most common liquid waste is aqueous, in which the waste materials are either dissolved in water or else evenly distributed in a liquid that is mainly composed of water. Such waste can be disposed of by dispersal into the sanitary sewage system (if low-level) or by other methods as approved by the RSO. The other common form of liquid waste is liquid scintillation cocktail, which is composed of volatile, flammable, toxic, organic material. This cannot be dumped into the sewage system; it must either be burned or evaporated. Other liquid waste, which is not soluble or readily dispersible in water, must be treated in accordance with specifications worked out in advance by the AU/PI and the RSO.

All liquid radioactive waste shall be stored and disposed of according to the following requirements:

a. Special containers for liquid waste shall be available in each laboratory where radioactive materials are use. Glass or heavy plastic jugs are satisfactory for this purpose.
2. All waste containers must be labeled with radioactive waste tags.
3. Liquid radioactive waste with a half-life less that 120 days shall be held for at least 10 half-lives and then disposed of as non-radioactive wastes.
4. Liquid waste with a half-life greater than 120 days shall be appropriately labeled and brought to the attention of the RSO for disposal.
5. Liquid scintillation media containing 0.05mCi or less of hydrogen-3 or carbon-14 per gram of medium may be disposed of without regard to its radioactivity. However, some scintillation cocktail media contain toxic organic solvents requiring special disposal. Contact the RSO and Risk Management before using such material.

6. A special sink for washing contaminated glassware should be designated and appropriately labeled.
7. There are many special problems involving chemical reactions between mixtures of liquid wastes. Disposal of cyanides into acidic liquid waste will result in the production of hydrogen cyanide, a very toxic gas. Special care also must be taken when disposing of tissue which has been digested in nitric acid, as oxides of nitrogen may be formed that could cause the waste container to explode. The AU/PI must ensure that chemical reactions will not occur in liquid waste containers

6. **Disposal of aqueous radioactive waste into sanitary sewerage**

Low activity aqueous waste may be disposed of through the sewer by flushing down laboratory sink drains. Rules and regulations limit the amounts and concentrations of radioactivity, which may be disposed of in this manner. According to NRC or WI Regulations, UWW may release annually, a total of five curies of H-3, one curie of C-14, and a total of one curie of all other isotopes, combined. Since there are a limited number of individual radioisotope labs at UWW, it is imperative that the RSO be informed of all individual releases of radioactive waste. Thus, no aqueous radioactive waste may be disposed of through the sewage system without prior approval. NOTE: If you have high activity aqueous waste, contact the RSO for disposal instructions.

Low activity aqueous waste may be disposed in designated laboratory sinks with prior authorization only, according to the following procedure:

a. Contact the RSO for authorization, unless the lab has been pre-authorized for aqueous waste disposal in the Campus Radiation Permit.
2. Inform the RSO before disposal into the sanitary sewer system so the RSO may coordinate total amount being discharged by all labs on campus.
3. Make sure the liquid waste being discharged is soluble or readily dispersible in water.
4. Adjust the pH of the waste to between 6.8 and 8.0.
5. Make sure you are using a sink clearly designated for radioactive use.
6. Know the flow rate of your sink. This can be accomplished by timing how long it takes to fill a container of known volume.
7. Determine total activity of the waste in microcuries by liquid scintillation counting.
8. Calculate the amount of each radioisotope that can be discharged by using information from similar discharges and information in 10 CFR 20, Appendix B.
9. Make sure the amount of each radioisotope does not exceed monthly and annual discharge limits.
10. Monitor sink before discharge begins.
11. Wear necessary PPE.
12. Discharge liquid waste slowly, with water running from the faucet to dilute it.
13. After discharge is complete, survey the sink and surrounding work surfaces to confirm that no residual material or contamination remained in the sink or on work surfaces.
14. Prior to leaving the area, decontaminate all areas or surfaces, if found to be contaminated.
15. Record the disposal in your records. You must maintain records of the quantity and concentration of each radioisotope released into the sanitary sewer system.

7. **Disposal of aqueous radioactive waste into sanitary sewerage**

Non-aqueous (less than 10% water content) waste shall be stored in spill-proof, unbreakable plastic containers of one to two gallon capacity. The containers must be approved by the RSO before use. Non-aqueous waste shall be free of all filterable solids before it can be collected for disposal by the RSO. For filtering liquid scintillation waste a 60 mesh metal screen is recommended. Under no circumstances should organic wastes go into the sanitary sewer system.

Preparing Organic Liquid Radioactive Waste for Pickup:

a. These instructions apply to organic liquid radioactive waste, not aqueous liquid waste.
2. Read the UWW RSM for details and guidelines governing management of radioactive waste.
3. Contact the RSO to request Radioactive Waste Contents tags.
4. The waste must be free of solids. Filter the waste through a 60 mesh metal screen.
5. The pH of the waste must be adjusted to between 6.8 and 8.0.
6. The activity of the waste must be determined. The activity can be determined by liquid scintillation counting.
7. If flammable, special criteria apply. Flammable materials must be labeled as such and handled appropriately. Contact the RSO and Risk Management for instructions prior to beginning work.

8. Prepare waste for pickup and complete Radioactive Waste Contents tag(s). Each carboy of liquid organic waste should have a tag attached to it.
9. Call the RSO (Office of Risk Management) to confirm pickup.
10. Record the disposal in your records.

8. **Liquid scintillation samples and vials**

   Organic solvent or liquid scintillation cocktail shall not be released into the sewage system under any circumstances. All liquid scintillation counting wastes shall be turned over to the RSO for disposal; EXPENSES FOR DISPOSAL SHALL BE CHARGED BACK TO THE AU/PI'S GRANT OR HOME DEPARTMENT. To prepare the waste for disposal, the user must verify the types of isotopes, the concentrations (mCi/ml), and the chemical form of the waste. This information must be attached to the waste container before it will be picked up.

   a. Liquid scintillation counting vials should be washed, decontaminated if necessary (see below), and either recycled or discarded as non-radioactive dry waste.
   2. Vials which contained media in which the concentration of C-14 or H-3 was originally less than 0.05 mCi/ml need not be decontaminated and should be disposed of with the regular, non-radioactive solid waste after having been properly emptied and dried.
   3. After contaminated containers have been washed, a representative sample of the batch just washed should be counted to determine the effectiveness of the washing. If the average count rate is less than twice the background level, the containers may be disposed of in the non-radioactive waste. Containers which cannot be sufficiently decontaminated must be disposed of in the solid radioactive waste after having been properly emptied and dried.
   4. The RSO will collect containers only if they cannot be decontaminated. It is conceivable that certain unique situations might present themselves in some laboratories. In such cases, exceptions to these procedures may be possible based upon prior approval by the RSO.
   5. Other than the obvious exceptions of Pasteur pipettes, syringes (glass or plastic), and hypodermic needles, items that may have come into contact with radioisotopes should not be placed into a radioactive sharps container without prior approval of the RSO. Routine washing (or an overnight soaking) can decontaminate most glass items (test tubes, vials, etc.) with an industrial strength detergent.

9. **Unacceptable disposal methods**

   **Specifically forbidden, wholly unacceptable methods** of disposal of radioactive waste:

   1. LIQUIDS IN SOLID WASTE. No liquids may be disposed of in the solid waste.
   2. DISPOSAL BY BURIAL IN THE SOIL. Under no circumstances shall personnel using radioisotopes bury any quantity of radioactive waste in the soil.
   3. UNAUTHORIZED DISPOSAL INTO THE SEWAGE SYSTEM. Under no circumstances shall radioactive waste be released into the sewage system without authorization of the RSO.

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## C. Audit Program

The NRC mandates that licensees review the local Radiation Safety Program on at least an annual basis in both content and implementation of the program. Think of this as a pre-emptive strike in preparation for NRC inspector visitation - it should help identify program weaknesses and allow licensee to take corrective action prior to inspection. Among the topics included in the audit are the following:

- Previous audits
- Organization and scope of the program
- Training, retraining and instructions to workers
- Internal audits
- Facilities
- Materials
- Leak tests
- Inventories
- Radiation surveys
- Receipt and transfer of radioactive material, including waste disposal
- Transportation
- Personnel radiation protection
- Notification and reports
- Posting and labeling
- Bulletins and information notices
- Special license conditions

Completion of the audit fulfills in part the requirements of 10 CFR 20.1101 for annual review to insure:

- Compliance with applicable NRC and DOT regulations, and the terms and conditions of the license;
- Occupational doses and doses to members of the public are ALARA (10 CFR 10.1101); and
- Records of audits and other reviews of program are maintained for 3 years. The audit is performed by the RSO alone, or aided by members of the HWRBS or the Risk Management Office. The various items are grouped below with a brief description of who has responsibility.

1. **Communication**

   The RSO is the central repository of information. Among these responsibilities is receiving notifications, reports, bulletins and other missives from the NRC and other regulatory agencies; the RSO sifts and refines and then shares pertinent information with the AU/PI. All incoming information is on file in the RSO's office, as are all outgoing memoranda. As part of the audit, the RSO will verify the presence of all such information.
2. **Radioactive materials records: inventory**

   Each AU/PI must have records of all radioactive materials currently in their laboratory; the RSO will have records of all materials on campus. During the annual audit, the RSO will confirm that these records are in agreement. This ensures accountability and aids in avoiding exceeding possession limits. Details for these records are described in Section IV.
3. **Radioactive materials records: receipt, transfer, and disposal**

   Each AU/PI must retain records of radioactive materials as specified by the NRC. Currently, this includes records of receipt (for as long as material is possesses and until 3 years after transfer or disposal), transfer (for 3 years after transfer), and disposal (until the NRC terminates the license). The RSO will have records of all materials on campus. During the annual audit, the RSO will confirm that these records are in agreement. Details for these records are described in Section IV.
4. **Personnel training**

   Each individual who handles radioactive materials must have training prior to beginning work. The depth of the training must be commensurate with the level of their proposed involvement. Thus, ancillary personnel and students observing a demonstration need orientation, and students participating in a single lab experiment need limited (although specific) training. Students working on research with a PI need more detailed coverage, while an AU/PI needs substantial background - 20 hours training and 20 hours experience. The RSO must complete a specialized 40-hour training course approved by the NRC. During the annual audit, the RSO will review use of radioactive materials on campus, update a list of all AU/PI (active and inactive status). In addition, she will compile a list of all trainees over the past time unit (year or six months), and verify agreement between work done and individual training status. It is the responsibility of the AU/PI to insure all their students are properly trained PRIOR to working with radioactive materials. It is also the responsibility of the AU/PI to provide direct supervision to students when radioactive materials are in use. Failure to do either of these may result in revocation of the Campus Radiation Use permit, and in loss of AU/PI status.

21. **Radiation monitoring equipment**

    Each laboratory in which radioactive materials are being handled must have and use radiation-monitoring equipment. The device should be appropriate for the type and amount of radioactivity in use. Devices will be calibrated on a regular basis (annually, twice a year) in accordance with manufacturers' specifications. The RSO is responsible for calibration; if an off-campus unit calibrates a device, the RSO will make arrangements or should be notified. Inform the RSO when new devices are purchased or received. A complete list of equipment on campus is available from the RSO.

22. **Surveys**

    Radiation surveys are used to detect and evaluate contamination of facilities, equipment, personnel, and areas (both restricted and unrestricted). All laboratories in which radioactive materials are used must be routinely surveyed to determine both radiation levels and removable contamination levels.

    a. **Leak testing sealed sources**

       Sealed sources containing radioactive substances over 100 microcuries of beta and/or gamma emitting material or over 10 microcuries of alpha emitting materials shall be leak tested at least twice a year by the RSO. The AU/PI must immediately report any suspected leakage to the RSO.

    2. **Radiation levels**

       Laboratories shall be monitored with a radiation survey meter sufficiently sensitive to detect 0.1 mR/hr. Radiation levels should be kept as low as is practical (0.25 mR/hr) but in no case should they exceed 2.5 mR/hr except under controlled circumstances for short time periods (10 minutes or less). Radiation levels in excess of 2.5 mR/hr that are detected in a survey shall require corrective steps to be taken to reduce the radiation to the acceptable limit.

    3. **Contamination levels**

       A series of wipe tests shall be taken in all areas where radioactive materials are handled in unsealed form. Contamination levels shall be kept as low as is practical and any count that exceeds the minimum detectable activity above background should be considered as an indication of contamination. Cleanup of the contamination must be made if the wipe test result exceeds 100 cpm above the minimum detectable activity. Contamination surveys must be sufficiently thorough to identify areas of contamination that might result in doses to workers or to the public. Combined removable and fixed contamination should be surveyed using appropriate radiation detection equipment. Removable contamination can be detected and measured through a wipe test of the surface, which is counted in an appropriate counting instrument, such as a liquid scintillation counter, a sodium iodide or germanium counter, or a proportional alpha/beta counter. Contamination surveys are performed:

       1. To identify radioactive contamination present on surfaces of floors, walls, laboratory furniture, and equipment;
       2. After any spill or contamination event;
       3. When procedures or processes have changed;
       4. To evaluate contamination of users and the work area, at the end of the day, when licensed material is used;
       5. In restricted areas based on the types and quantities of materials in use but not less frequently than monthly;
       6. In areas adjacent to restricted areas and in all areas through which licensed materials are transferred and temporarily stored before shipment. The AU/PI or an advanced student will do a survey of the work area at the end of the session or at the end of the day. The AU/PI or an advanced student will do a formal survey of the entire restricted area within their domain at least once a month. The RSO will do a formal survey of all restricted areas once per year. During the annual audit, the RSO will verify

that records are in order, that any contamination has been identified, and that any previously identified contamination had been removed.

4. **Frequency of surveys**

   The AU/PI needs to perform a survey of the work areas at the end of each day in which radioactive materials are used. General surveys of the entire laboratory need to be conducted regularly, the frequency based on the types and amount of radionuclides being used. Different methods for determination of survey frequency are outlined below. The RSO shall conduct both radiation levels and removable contamination surveys on a regular basis.

   Personnel must survey for contamination in locations where individuals are working with significant amounts of radioactive materials. This may include an unsealed form of radioactive material in an amount greater than or equal to 10 percent of the smallest annual limit on intake (ALI) (either the inhalation or ingestion ALI) listed for that radionuclide in 10 CFR Part 20. These surveys should be done at a frequency appropriate to the types and quantities of radioactive materials in use, but at a minimum monthly. If amounts are used that are greater than or equal to the smallest ALI listed for that radionuclide, then surveys should be performed at least monthly. The RSO suggests performing a survey as recommended by NRC Regulatory Guide 8.23 (see Table 11).

   Alternatively, surveys can be performed based on classification of the laboratory, taking into account the type and amount of radionuclides in use (see Table 12 & 13). Considering the type of activities in which radionuclides are used can further amend this (see Table 14). The object in using these tables is to determine how frequently to survey the laboratory. To do this, multiply the activity range under survey frequency (LOW, MEDIUM and HIGH) by the appropriate Modifying Factor to construct a new set of uCi ranges for LOW, MEDIUM and HIGH survey frequency.

   LOW **-** Not less than once a month.
   MEDIUM **-** Not less than once a week.
   HIGH **-** Not less than once per normal working day.

   EXAMPLE: A laboratory is classified as Medium Frequency for surveying purposes. If simple chemical operations were being performed, 10mCi could be handled. If simple aliquot preparation was being performed in a lab with a Medium Frequency rating for surveys, then (10 x 10mCi) = 100mCi could be used. If dry grinding was being performed, then only (0.01 x 10mCi) = 100uCi would be allowed.

5. **Summary of RSO functions in audits**

   As part of the Radiation Safety Program, the RSO must maintain records on the status of each AU/PI, and total amounts and forms of all radioactive materials. Among the duties and responsibilities of the RSO are the following:

   1. Verify all radiation survey instruments are calibrated each six months or after servicing. Approved users shall be responsible for calibrating their own survey instruments.
   2. Direct and monitor the disposal and record keeping of all radioactive wastes.
   3. Approve ordering, receiving, storing, processing, and dispensing of all radioactive materials, including maintaining records of them.
   4. Conduct a physical inventory of all radioactive sealed sources each six months.
   5. Perform contamination surveys in all laboratories in which radioactive substances are used, at least monthly. Investigate any detectable contamination to determine causes and take necessary action to remove contamination and prevent further occurrences.
   6. Perform leak tests every six months of all sealed sources containing radioactive substances over 100 microcuries of beta and/or gamma emitting material or over 10 microcuries of alpha emitting material.
   7. Review contamination survey reports submitted by approved users and take necessary action.
   8. Perform quarterly compliance inspections of laboratories using radioactive materials and take necessary corrective action.
   9. Maintain an inventory of all radionuclides and limit the quantity of radionuclides at the university to the amounts authorized by the NRC license. (items from Table 1)

The RSO must therefore make periodic visits to each laboratory to check records, conduct surveys, etc.

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# Section VII

## VII. Problem Solving - Emergency and Decontamination Procedures

Emergencies resulting from accidents in radionuclide laboratories may range from minor spills of radioactive materials; involving relatively no personal hazard, to major radiation incidents and spills involving extreme hazards and possible bodily injury. Because of the numerous complicating factors that may arise, and because of the wide range and variety of hazards, set rules of emergency procedure cannot be made to cover all possible situations. In any emergency, however, the primary concern must always be the protection of personnel from radiation hazards. The secondary concern is the confinement of contamination to the local area of the accident if possible.

**A. Spills**

"Spills: In the event of a spill of liquid radioactive material, immediate removal of all unnecessary personnel will be accomplished. As persons are removed from the area, they will be screened for contamination on body and clothing, especially hands and shoes. The area then will be sealed off. Experienced faculty members (a member of the radiation safety committee) will, with proper protective clothing (gloves, slippers and aprons), identify the area of the spill and any possible carry-off on hands or shoes. Procedures will then be initiated to clean up the spilled substances if possible and the resultant contaminated material dispensed of at commercial burial sites. If local people cannot clean up spill, professional decontamination people will be brought in as soon as possible. In the meantime, the area will be sealed off."

**- From UWW 1994 NRC-313 Application, Item 10: Radiation Safety Program, pp. 11-18**

1. Minor spills - involving no radiation hazard to personnel
2. Major spills - involving radiation hazards to personnel.

## B. Emergency/Catastrophe Situations:

1. "Fire: Local fire department shall be kept informed on the presence of radioactive materials and where they are stored and used. In the event of a fire, the area where radioactive materials are stored will be sealed off and the NRC Regional Office notified. If survey equipment is intact, the extent of contamination will be isolated. Depending upon degree and extent of contamination, help from NRC will be solicited in cleaning up the contamination.
2. Explosion: Similar procedures will be followed as described above for fire. Most important will be to seal off the area as soon as possible and to insure no contamination has occurred and been carried off by personnel and

equipment. Again, the NRC will be notified as soon as possible of such occurrence and help of the regional NRC office will be sought.

3. Other accidents such as aircraft crash, earthquake, etc., will be handled in a manner similar to an explosion."

**- From UWW 1994 NRC-313 Application, Item 10: Radiation Safety Program, pp. 11-18**

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## RADIATION EMERGENCY PROCEDURES

A. **Minor spills - involving no radiation hazard to personnel**
   1. **Notify all other persons in the room at once.**

   2. **Permit only the minimum number of persons necessary to deal with the spill into the area.**

   3. **Confine the spill immediately.**
      a. **Liquid spills - Don protective gloves. Drop absorbent paper on spill.**
      - **Dry spills - Don protective gloves. Dampen thoroughly, taking care not to spread contamination. (Water may be used except when a chemical reaction with water would generate an air contaminant. Oil should then be used.)**

   4. **Notify the RSO as soon as possible. The RSO will monitor all personnel involved for bodily concentration and will recommend further steps necessary for final cleanup of the spill.**

   5. **Permit no one to resume work in the area until approval of the RSO is secured.**

2. **Major spills - involving radiation hazards to personnel.**

   1. **Notify all other persons not involved in the spill to vacate the room at once.**

   2. **Make no immediate attempt to clean up the spill.**

   3. **If the spill is on the skin, flush thoroughly with water. If the spill is on clothing, discard outer clothing at once. (Spare clothing is kept near radiation use areas.)**

   4. **Switch off all fans.**

   5. **Vacate the room and prohibit entrance to contaminated area.**

   6. **Notify the RSO as soon as possible, giving all details of the spill. The RSO will monitor all personnel**

**involved for bodily concentration and will recommend further steps necessary for final cleanup of the spill.**

7. **Permit no one to resume work in the area until approval of the RSO is secured.**
8. **Under no circumstances should an untrained person attempt to examine or clean up the radioactive material.**

   **The preceding procedures are based on recommendations made by the National Committee on Radiation Protection as set forth in the National Bureau of Standards Handbook 48.**

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## Table 4. Classification of UWW Population Relative to Potential Exposure to Radioactivity

| Potential for Exposure | Members of the UWW Community |
|---|---|
| Moderate to High | RSO, AU/PI |
| Low | Students in restricted area classrooms, ancillary personnel in restricted laboratories (techs); ancillary personnel (maintenance) |
| Very low | Students in the building, UWW personnel in the building, students & UWW personnel on campus, Administration, general public. |

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***Table 5. Classification of Radionuclides by Relative Radiotoxicity Per Unit Activity***

| Group | Relative Toxicity | Radionuclides |
|---|---|---|
| **1** | **Very High** | **Pb-210 Pu-241 Cf-252 Ra-226 Po-210 Am-241** |
| **2** | **High** | **Na-22 Cl-36 Ca-45 I-131 Co-60 Sr-89 Sr-90 Cs-137** |
| **3** | **Moderate** | **C-14 P-32 S-35 Cr-51 Fe-59 Ni-65 Mo-99 Rn-222 I-125 Co-58** |
| **4** | **Slight** | **H-3 Th-natural U-natural Zn-69** |

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**Table 6. Action Factors (A) for Various Operations Using Radioactive Materials**

| Type of Operation | Action Factors |
|---|---|
| **1. Simple storage** | **x 0.01** |
| **2. Very simple wet operations (e.g., preparation of aliquots of stock solutions). EXAMPLES = Diluting stock solutions, sealed ultra centrifugation, washing precipitates, in vitro incorporation or incubation, etc.** | **x 0.1** |
| **3. Normal wet chemical operations (e.g., analysis, simple chemical preparations). EXAMPLES = Precipitation, filtration, bench type centrifugation, solvent extraction, chromatography, pipetting or titrating, preparing aliquots of stock solutions, gel electrophoresis.** | **x 1** |
| **4. Complex wet operations (e.g., multiple operations or operations with complex glass apparatus). EXAMPLES = Distillation, homogenization, evaporation to dryness. ALSO: simple dry operations with non-respirable** | **x 10** |

| | |
|---|---|
| **particles (fusion reaction, fluorination, transfer of dry precipitates, etc.** | |
| **5. Simple dry operations (e.g., manipulation of powders) and work with volatile radioactive compounds.** | **x 10** |
| **6. Exposure of general public (non-occupational, non-educational).** | **x 100** |
| **7. Dry and dusty operation (e.g., grinding). EX. = Operations that may produce respirable size particles (dry powders, gaseous forms {except tritium & noble gases}, aeration of liquids, use of highly volatile or highly exothermic reactions.** | **x 100** |

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## Table 7. Hazard Factors (H) Associated with Different Forms of Radioactive Materials

| Form of Radioactive Material | Hazard Factor |
|---|---|
| **Insoluble or non-metabolizable liquids, solids, or gases.** | **0.01** |
| **Metabolizable organic or inorganic compounds.** | **1.0** |
| **Nucleic acids and precursors (not P-32 phosphates).** | **10.0** |
| **Skin permeable liquids [DMSO, tritiated water], high specific activity (> 100mCi/ml) radioactive materials.** | **x 10** |
| **5. Simple dry operations (e.g., manipulation of powders) and work with volatile radioactive compounds.** | **10.0** |
| **Carcinogens, explosives, extreme toxins.** | **100.0** |

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## Table 8. Effective Maximum Radioisotope Quantity (Qeff) as a Function of Toxicity Class

| | Workplace Type | | |
|---|---|---|---|
| **Radionuclide** | **A** | **B** | **C** |
| **Toxicity Class** | **Chemical Lab** | **Chem Lab with Fume Hood** | **Radioisotope Lab** |
| **Very High** | **0.1 uCi** | **10 uCi** | **1 mCi** |
| **High** | **1 uCi** | **100 uCi** | **10 mCi** |
| **Moderate** | **100 uCi** | **10 uCi** | **100 mCi** |
| **Slight** | **1 mCi** | **100 mCi** | **1 Ci** |

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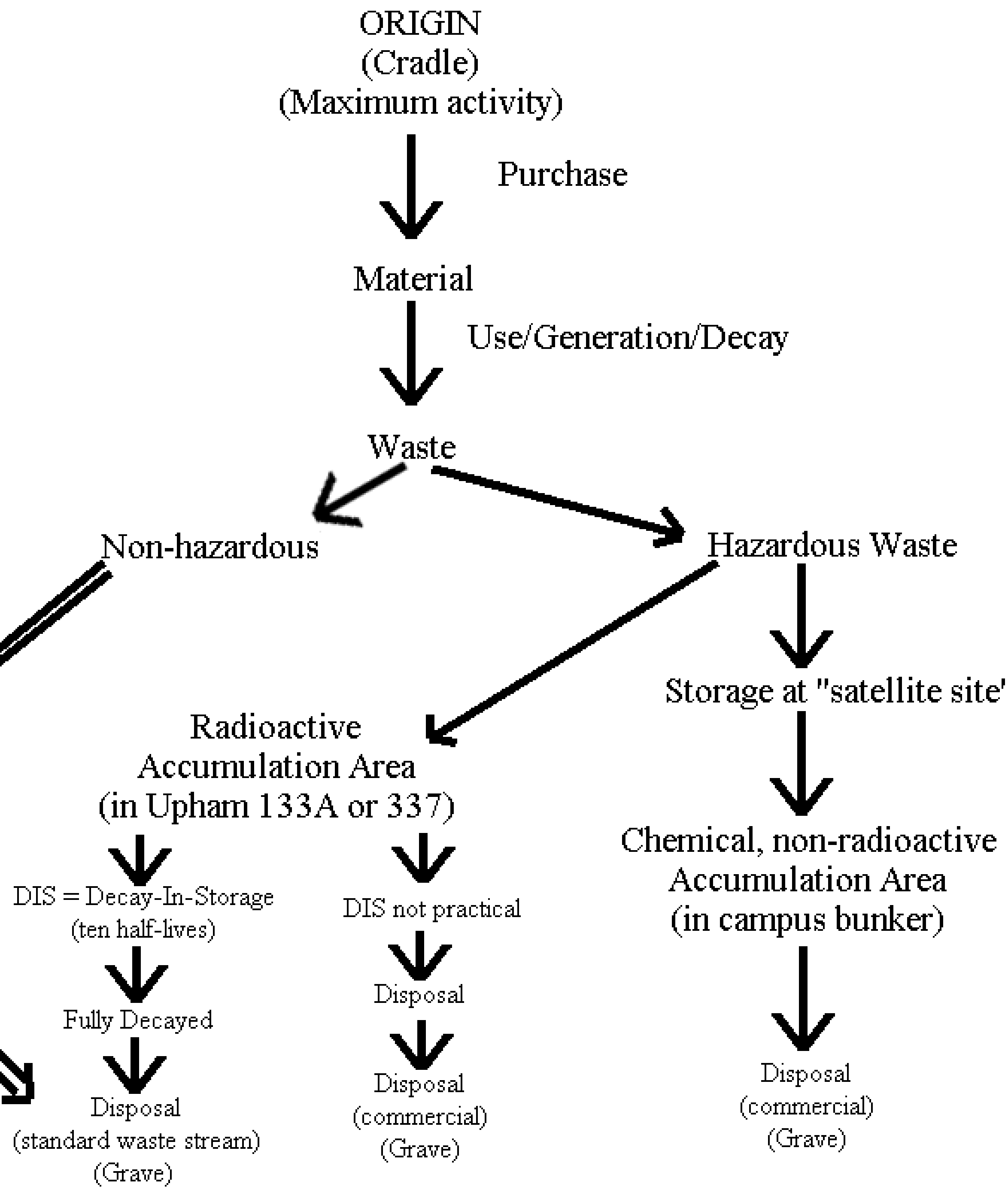
**Figure 1. Basic Stages of Radioactive Materials Management**
(adapted from Reinhardt and Gordon, 1991)

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# Abbreviations

| | | | |
|---|---|---|---|
| ALARA | As Low As Reasonably Achievable | ml | milliliter |
| ALI | annual limit of intake | mR | milliRoentgen |
| AMAD | activity median aerodynamic diameter | mrem | millirem |
| ANSI | American National Standards Institute | mSv | milliSievert |
| AU | authorized user | mCi | milliCurie |
| bkg | background | NaI | sodium iodide |
| BPR | Business Process Design | NCRP | National Council on Radiation Protection & Measurements |
| Bq | Becquerel | NIST | National Institute of Standards & Technology |
| CDE | committed dose equivalent | NMSS | Office of Nuclear Material Safety and Safeguards |
| CEDE | committed effective dose equivalent | NRC | United States Nuclear Regulatory Commission |
| CD-ROM | compact disc - read only memory | NVLAP | National Voluntary Laboratory Accreditation |
| CFR | Code of Federal Regulations | OCFO | Office of the Chief Financial Officer |
| Ci | Curie | OCR | optical character reader |
| cpm | counts per minute | OMB | Office of Management and Budget |
| DAC | derived air concentration | OSP | Office of State Programs |
| DCF | dose conversion factor | P&GD | Policy and Guidance Directive |
| DDE | deep dose equivalent | R | Roentgen |
| DFP | decommissioning funding plan | RAM | radioactive material |
| DIS | Decay-In-Storage | RG | Regulatory Guide |
| DOE | United States Department of Energy | RQ | reportable quantities |
| DOT | United States Department of Transportation | RSO | Radiation Safety Officer |
| dpm | disintegrations per minute | HWRBS | Hazardous Waste and Radiation and Biological Safety Team |
| dps | disintegrations per second | SDE | shallow dose equivalent |
| EDE | effective dose equivalent | SI | International System of Units (from the French "Le Systeme Internationale d'Unites") |
| EPA | effective dose equivalent | SS&D | sealed source and devices |
| F/A | financial assurance | SSD | sealed source and device |
| FR | Federal Register | std | standard |
| GBq | gigaBequerel | Sv | Sievert |
| GC | gas chromatograph | TEDE | total effective dose equivalent |
| G-M | Geiger-Muller | TI | transportation index |
| GPO | Government Printing Office | TLD | thermoluminescent dosimeters |
| Gy | Gray | TODE | total organ dose equivalent |
| ICRP | International Commission on Radiological Protection | XRF | X-ray fluorescence (analyzer) |
| IN | Information Notice | | |
| LLW | low level radioactive waste | | |
| LSA | low specific activity | | |

| | |
|---|---|
| LSC | liquid scintillation counter |
| MBq | megaBecquerel |
| mCi | milliCurie |
| mGy | milliGray |