Guide to the Safe Use of Radionuclides at the University of Wisconsin-Milwaukee

For Authorized Users

Radiation Safety Program
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University Safety and Assurances
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Section 1 – UWM Radiation Safety Program

The University of Wisconsin-Milwaukee is licensed by the Department of Health Services to use accelerator produced radionuclides, naturally occurring radionuclides, and machine produced radiation (License Number: 079-1324-01). DHS requires that the use of radiation and radionuclides be strictly controlled to ensure that both the people using the materials and members of the general public receive as little radiation exposure as possible. At UWM, the program organization is as follows:

Figure 1. Organization of the Radiation Safety Program at UWM

1.1 Chancellor
The Chancellor at the University of Wisconsin-Milwaukee is ultimately responsible for the effective operations of the campus Radiation Safety Program.

1.2 Vice Chancellor – Finance and Administrative Affairs
The Vice Chancellor serves as the certifying official for the University’s license activities and will ensure that sufficient resources are available to support the campus Radiation Safety Program.
1.3 **Director/Associate Director – University Safety and Assurances**
The campus Radiation Safety Program is part of University Safety and Assurances within the division of Finance and Administrative Affairs. The Associate Director has been delegated administrative responsibility for the campus Radiation Safety Program.

1.4 **Radiation Safety Program**
The Radiation Safety Program is the combined personnel, offices, laboratories, and administrative responsibilities which make up the radiation protection and control service at UWM. The Radiation Safety Program ensures that UWM Faculty, Staff and Students comply with all Federal, State and University radiation safety regulations. The Radiation Safety Program (also referred to as Radiation Safety) has its main office in Lapham Hall, Room W217. The Radiation Safety Laboratory is located in Lapham Hall, Room 218. All radioactive material orders are checked in and dispensed from Lapham Hall 218.

1.5 **Radiation Safety Officer/Program Manager**
The Radiation Safety Officer (RSO) manages the campus Radiation Safety Program. The RSO remains abreast of current Federal and State regulations concerning the use of radioactive materials and ensures that DHS license conditions are met by authorized users of radioactive materials and radiation workers. The RSO is responsible for implementing the tasks and procedures associated with the University’s Radiation Safety Program, including monitoring, surveying, testing, records maintenance, reporting and enforcement as mandated by DHS. The RSO is available to consult with researchers who are preparing proposals, who are currently engaged in research utilizing radionuclides, and those who utilize radioactive materials in laboratory courses.

1.6 **Authorized Users**
Authorized Users are faculty members or accredited scientists whose written application for authorization to possess and use radioactive materials has been approved by DHS. The Authorized User is the foundation of the campus program. Since the Authorized User is most familiar with the details of their research and teaching, it is the User’s responsibility to assure that their research program and/or teaching activities comply with DHS license conditions and that their laboratory staff utilize radioactive materials in a safe manner. This is a responsibility that cannot be delegated.

1.7 **Radiation Workers**
Radiation Workers are individuals who use radioactive materials or machines which produce radiation. These individuals must be trained by and work under the supervision of an Authorized User. Radiation Workers must read the handbook, *Radiation Safety for Laboratory Workers* and take and pass the associated exam. Additional information on training is found in Section 6, Personnel Training.

1.8 **Laboratory Workers**
Laboratory Workers are individuals who work in laboratories where others are using radioactive materials, but who do not handle or work with those materials. All Laboratory Workers must read the handbook, *Radiation Safety for Laboratory Workers* and take and pass the associated exam. Additional information on training is found in Section 6, Personnel Training.
Section 2 – Obtaining Radionuclide Authorizations

2.1 New Authorization

To obtain “Authorized User” Status, RS Form 100, Application for Possession and Use of Radionuclides, (Appendix A) must be completed and submitted to the Radiation Safety Program. Complete ALL items on the application form and attach additional sheets as necessary. The RSO will review the qualifications of applicants and submit the information to DHS for approval. This process may take up to 30 days.

When completing the application for authorization to use radioactive materials, pay particular attention to the following:

- All restricted and controlled areas must be locked when unattended. Materials stored in unrestricted areas must be secured from unauthorized removal or attended under constant surveillance as indicated in 10 CFR 20.1801 and 20.1802. Additional information on the security or radioactive materials is found in Section 9.
- The radionuclide “Possession Limit” is the amount of activity an Authorized User plans to have “on hand” at any given time in any form (i.e., stock solution, tagged samples or waste)
- Please provide information pertaining to the anticipated use for each nuclide for which authorization is requested. Justification for particularly large order and possession limits should be included here. Attach written procedures and protocols.
- All personnel must complete the radiation safety exam. For particularly radiotoxic nuclides, unusual procedures or large quantities, please describe additional training that will be provided. Information on required training for all laboratory personnel is found in Section 6.
- If radioactivity is to be administered to live animals, RS Form 120, Animal Use of Radionuclides, (Appendix B) must be completed and submitted with the application. Additionally, all appropriate Federal, State, and University animal handling requirements, as specified in the UWM Animal Care Guide, must be followed. The special requirements for the use of radioactive materials in animals are outlined in Section 17. Contact the UWM Animal Care Program office at 229-6016 for more information on general research animal use.
- If student use is anticipated, the user must abide by classroom guidelines and make arrangements for appropriate training. Information on the requirements for the use of radionuclides in student labs is provided in Section 18.
- DHS places strict conditions on the use of radioiodine. Detailed information is required for all work involving radioiodinations. The specific requirements for the use of radioiodine UWM are discussed in Section 14.

The University’s DHS license does not recognize any quantity of radioactive material as exempt from authorization unless it is in a sealed standard or check source. Please contact the Radiation Safety Program if you have questions regarding any material you plan to use of have in your possession.
2.2 Training and Experience

Before authorization may be granted by DHS, the applicant must have adequate training and experience with the radionuclides that he/she will be using related to the radionuclide laboratory classification scheme (see Section 5, Laboratory Classifications). Training and experience information should be provided on RS Form 100 (Appendix A). If the applicant does not meet the criteria outlined below, additional training and education will be required to bring the applicant to a training level for further consideration for Authorized User status.

The minimum training and experience to qualify as an Authorized User is as follows:

- **Laboratory Type 1**
  - A college degree at the Bachelor level, or equivalent training and experience, in such areas as physical, chemical, biological, biomedical, veterinary, or engineering sciences, and;
  - At least 40 hours of training and experience in the safe handling of radioactive materials, the characteristics of ionizing radiation, units of radiation dose and quantities, radiation detection instrumentation and biological effects of radiation exposure appropriate to the types and forms of byproduct material used.

- **Laboratory Type 2**
  - Minimum qualifications for Type 1 laboratory, plus an additional 40 hours of training and experience with the quantities of radionuclides, or similar radionuclides, proposed for use.

- **Laboratory Type 3**
  - Minimum qualifications for Type 1 laboratory, plus one year combined training and experience with the quantities of radionuclides, or similar radionuclides, proposed for use.

- **Laboratory Type 4**
  - Minimum qualifications for Type 1 laboratory, plus two years combined training and experience with the quantities of radionuclides, or similar radionuclides, proposed for use.

2.3 Amendments to License

Requests for changes in authorizations are possible by submitting a letter, RS Form 100, or Form 150 (Appendix D) indicating the desired change. Written notification will be sent to you as soon as the amendment is approved by DHS (may take up to 30 days). Contact the Radiation Safety Officer for more information on amendments.

2.4 Authorized User Absences

When an Authorized User is going to be absent for more than 30 days, his or her authorization must be transferred to another Authorized User. This ensures that someone is responsible for the activities of each laboratory at all times. Contact the Radiation Safety Program for more information on this before your intended absence.
2.5 Termination of Authorization

An authorization may be terminated at the request of the Authorized User after all radionuclides are properly disposed of or transferred to another Authorized User and a final survey of the radionuclide facilities assigned to the Authorized User shows that these areas are free of contamination. Authorized Users who will be leaving the University are expected to terminate their authorization in a timely manner prior to their departure. An authorization may be revoked by the Radiation Safety Officer for flagrant disregard of the radiation safety guidelines or for repeated or intentional violation of the DHS regulations.

If you have difficulty completing any of the application forms or have any questions please call the Radiation Safety Program at 430-7507.

Section 3 - Receiving Sources and Transferring Radionuclides

All radioactive materials brought to or removed from UWM must be authorized, inventoried and inspected by the Radiation Safety Program. Even small amounts of radionuclides, which would qualify as "exempt quantities" at institutions without DHS licenses, must be registered with the Radiation Safety Program. Only Authorized Users are permitted to receive radioactive materials.

3.1 Ordering Radionuclides from Commercial Vendors

Pre-Ordering

Before an Authorized User can instruct his or her department to order radioactive materials, the Radiation Safety Program must be consulted to verify that the applicant is properly authorized and to assure that the use of the radioactive material falls within the permissible scope of UWM's DHS license. As previously mentioned, only Authorized Users who have current application on file with the Radiation Safety Program can receive radioactive materials.

Any laboratory personnel ordering radioactive material on behalf of an Authorized User must be registered with the Radiation Safety Program as a Radiation Worker. Orders can only be released to persons who have proper training and experience and whose records are on file. Any person ordering high level beta or gamma emitting radionuclides in quantities greater that 1.0 mCi must have a dosimetry badge. Dosimeters are provided by the Radiation Safety Program free of charge to University personnel who need them. More information on dosimeters is provided in Section 7.

Ordering Through the UWM Purchasing Department

All orders for radioactive materials must be approved by the Radiation Safety Program before they are placed by the UWM Purchasing Department. Orders will be checked for conformance with DHS license conditions, necessary information will be recorded, and the requisition will be forwarded to the UWM Purchasing Department. The item(s) ordered on the requisition cannot be changed without prior approval of the RSO. Delivery of the order must be made directly to the Radiation Safety Program. The delivery address is:
We can complete the address portion of the requisition for you, if desired, to ensure proper delivery. Note, UWM’s DHS license specifically indicates that all orders of radioactive material must be delivered to the Radiation Safety Program, Lapham Hall, Room W217.

“Phone-In” Orders

Orders placed directly with a vendor by an Authorized User or departmental official through blanket orders or confirming requisitions must also be approved by the Radiation Safety Program at the time of the order. Call 430-7507 for approval and provide information regarding vendor name, purchase order number, and the anticipated delivery date.

Receipt of Radioactive Materials

Packages of radioactive materials must be delivered to the Radiation Safety Program, Lapham Hall, Room W217, between the hours of 7:00 A.M. to 4:00 P.M., Monday through Friday (excluding holidays). Upon receipt, the packages are checked for radioactive contamination and the contents are inventoried before they are released to the user (Appendix E).

After an order has been received and checked in, the Authorized User or his/her representative will be contacted to pick up the material. The Radiation Safety Program does not have the facilities to hold radionuclides shipped on dry ice for more than a few hours, therefore, those items must be picked up as soon as possible. We can assume no responsibility for radioactive material spoilage.

3.2 Transfer of Radioactive Material

Radioactive materials obtained by means other than through a purchase order must also be approved by the Radiation Safety Program to ensure compliance with DHS regulations. This includes transfers of material between campus users or from off campus sources. At the time the transfer is approved, an inventory number may be assigned for control and tracking purposes.

On Campus Transfers

As previously mentioned, the Radiation Safety Program is required by the DHS to keep careful inventory records of all radioactive materials on campus. This includes keeping track of the actual users of the material and the physical location of the material. If radioactive materials are transferred from one user's lab to another we must be involved. Additionally, it is the responsibility of all labs to maintain up-to-date records of the use, transfer and disposal of radioactive materials assigned to them. For these reasons the following procedures must be followed when performing inter-lab transfers of radioactive materials.
The Radiation Safety Program must be notified of all transfers of radioactive material from one lab or authorized user to another. It is the responsibility of the lab receiving the material (the borrower) to report transfers.

- To report a transfer of material, phone the Radiation Safety Program office at 430-7507 and report the:
  - Name of Authorized User the material is transferred from,
  - Name of Authorized User the material is transferred to,
  - Isotope and Quantity transferred in µCi or mCi,
  - Number of the material,
  - Lot number of the material.

- The amount transferred must be documented on the inventory sheet provided with that material to the original user. When you initial the inventory sheet, also indicate the lab or user that the material was transferred to.

- "Use" of radioactive material is considered to be any time that material is taken out of a source vial or is in any way aliquoted. If you aliquot material in a lab that is not your own you must perform a survey of the area and document the results to ensure that there is no residual contamination. Check with personnel in the lab you are using for instruction on their monitoring and documentation procedures.

- When a transfer is reported the Radiation Safety Program, a radioactive material control sheet and inventory form for the lab receiving the material and a radioactive material disposal form for the lab that the material was taken from will be completed. User inventory records will be updated and forwarded to each lab for inclusion in the labs permanent records.

Transfer of Radioactive Material to an Off-Campus Recipient

Transfers of radioactive material to off campus sites, including the Medical College of Wisconsin (MCW), must first be approved by the Radiation Safety Program, regardless of the quantity. Approval is needed to ensure that the recipient is licensed to receive the material that proper shipping documentation is prepared to meet DHS and Department of Transportation (DOT) regulations, and that proper monitoring and packaging procedures are followed (see Section 19, Radioactive Materials Transportation). If a shipping service such as Federal Express or Airborne Delivery will be utilized, a requisition or account number must be provided for billing purposes.

Please note, it is illegal to send radioactive materials through the U.S. mail. The Radiation Safety Program must also have a copy of the recipient institution's License on file before the transfer can be made. This is required by federal law. Please call 430-7507 for more information about radionuclide transfers and shipments off-campus.

Transfer of Radioactive Material to UWM from an Off-Campus Source

The Radiation Safety Program must be notified in advance of the anticipated receipt of radioactive material from any source. This includes material from MCW, other institutions, free samples, evaluation shipments, custom synthesis, etc. As noted earlier, all radioactive materials must be shipped to the Radiation Safety Program. After the package has been checked in and inventoried, it will be released to the Authorized User. If radioactive materials are ever delivered directly to your laboratory or your departmental office, place the package in a secure location and call our office, 430-7507, at once!
Section 4 – Facilities for the Use and Storage of Radionuclides

The Authorized User is responsible for ensuring that adequate facilities are available for the use and storage of radionuclides in their possession.

4.1 Radioactive Materials Facilities

Radioactive materials may be used only at the following UWM facilities as authorized by DHS: Main (Kenwood) Campus; the Great Lakes WATER Institute, 600 E. Greenfield Avenue (See Section 20); and aboard Authorized UWM Research Vessels (See Section 21).

4.2 The Radionuclide Laboratory

A radionuclide laboratory is an enclosed space separated from adjacent areas by a floor, ceiling, and fixed walls with closable and lockable doors and windows. If unsealed sources of radioactive materials are used anywhere within the enclosure, the entire room is considered a radioactive materials area.

4.3 Shielding

The Authorized User must provide and use adequate shielding so that exposure to individuals working with or near radioactive materials are kept as low as reasonably achievable (ALARA; See Section 11).

4.4 Fume Hoods

Fume hoods must have adequate air flow to ensure that airborne radionuclide levels in restricted or controlled areas and exhaust effluents are maintained below the allowed effluent concentrations established by the DHS. Wisconsin Department of Commerce codes require an average face velocity of 100 FPM (feet per minute). Typically, radionuclide fume hoods must have a discharge rate of <1000 CFM (cubic feet per minute). Consult with University Safety and Assurances at 229-6339 to have your hood tested. Contact the Radiation Safety Program before using volatile radioactive materials in hoods. Special hood requirements when using radioiodine and other volatile radionuclides are discussed in Section 14.

4.5 Security

Radioactive materials, including wastes, must be secured against unauthorized removal. Authorized Users are responsible for the security of all radioactive materials in their possession including radioactive wastes in storage. See Section 9 for more information on security.

Anyone who suspects that radioactive material has been lost or stolen, must contact the Radiation Safety Program IMMEDIATELY.

Section 5 – Radionuclide Laboratory Classification

Each laboratory in which radioactive materials are used is classified as a Type 1, 2, 3 or 4 laboratory. These lab types define the minimum facility and equipment requirements for the use of various types and quantities of radioactive materials that are used within each laboratory.
Using the table at the end of this section, the laboratory type is based on the relative toxicity and the authorized possession limits of the radionuclides involved.

5.1 **Laboratory Type 1 – General Purpose Laboratory**

Floors, walls and working surfaces made of materials that are easily kept clean. At least one sink shall be available. Radionuclide working areas should have adequate lighting. There shall be sufficient space designated for accumulating and storing radioactive waste. If the physical form of the radioactive material is such that the material can readily become airborne, then ventilation is necessary.

5.2 **Laboratory Type 2 – Basic Chemical Laboratory**

All requirements of Laboratory Type 1. Additionally, floors, walls and working surfaces shall be made of low porosity materials or well-sealed. Working surfaces shall be covered with absorbent paper or other suitable absorber, laboratory must have adequate exhaust ventilation, and the shielding needs for beta and gamma ray materials must be assessed.

5.3 **Laboratory Type 3 – Dedicated Chemical Laboratory**

All requirements for Laboratory Types 1 & 2. Additionally, floors and walls made up of materials that do not readily absorb; fume hood of adequate design and flow rate (minimum 100 linear feet per minute face velocity), working surfaces of non-absorbable material and/or covered with absorbent paper or other suitable absorber, or work performed in trays made up of non-absorbent materials.

5.4 **Laboratory Type 4 – Specialized Laboratory**

Specific requirements depend on radionuclide and/or combinations of radionuclides; quantities of the radionuclides or combinations thereof; and chemical and physical form of the radionuclides. For quantities greater than 10 times those listed, special shielding, handling devices, ventilation, glove boxes, etc. may also be required.
Table 1 – Radioactive Laboratory Classification Scheme

<table>
<thead>
<tr>
<th>Radionuclides</th>
<th>Relative Radiotoxicity</th>
<th>Lab Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>$^{3}$H, $^{14}$C, $^{18}$O, $^{51}$Cr, $^{72}$Ge, $^{85}$Kr, $^{99m}$Tc, $^{113m}$In, $^{133}$Xe</td>
<td>Low</td>
<td>&gt;10,000 mCi</td>
</tr>
<tr>
<td>$^{33}$P, $^{35}$S, $^{47}$Ca, $^{47}$Sc, $^{55}$Fe, $^{57}$Co, $^{67}$Ga, $^{72}$Ga, $^{99m}$Mo, $^{103}$Pd, $^{115}$Cd, $^{141}$Ce, $^{177}$Lu, $^{197}$Hg, $^{201}$Tl, $^{203}$Tl</td>
<td>Medium - Low</td>
<td>&lt;1,000 mCi</td>
</tr>
<tr>
<td>$^{22}$Na, $^{32}$P, $^{38}$Cl, $^{42}$K, $^{48}$Ca, $^{48}$Sc, $^{54}$Mn, $^{58}$Co, $^{59}$Fe, $^{63}$Ni, $^{6}$Zn, $^{74}$As, $^{76}$Se, $^{85}$Sr, $^{86}$Rb, $^{90}$Y, $^{95}$Nb, $^{99}$Tc, $^{103}$Ru, $^{105}$Ag, $^{109}$Cd, $^{111}$In, $^{113}$Sn, $^{121}$I, $^{129}$mTe, $^{129}$I, $^{132}$Te, $^{140}$Ba, $^{140}$La, $^{147}$Pm, $^{152}$Gd, $^{192}$Ir, $^{169}$Yb, $^{198}$Au, $^{203}$Hg</td>
<td>Medium</td>
<td>&lt;100 mCi</td>
</tr>
<tr>
<td>$^{60}$Co, $^{125}$I, $^{131}$I, $^{134}$Cs, $^{137}$Cs, $^{144}$Ce</td>
<td>High</td>
<td>&lt;10 mCi</td>
</tr>
<tr>
<td>$^{90}$Sr, $^{210}$Po</td>
<td>Very High</td>
<td>&lt;0.1 mCi</td>
</tr>
</tbody>
</table>

For other radionuclides listed in 10 CFR 33.100 the lab classification will be determined by matching the activity in Schedule A, Column II with the activity in the Lab Type 2 Column of this table.

Section 6 – Personnel Training

It is the Authorized User’s responsibility to ensure that their personnel are properly trained in radiation safety techniques. Minimum training requirements are given below.

6.1 Radiation Workers

All persons who work with radioactive materials or radiation producing machines must read the manual "Radiation Safety for Laboratory Technicians" prepared by the Radiation Safety Program, and take and pass the associated exam (Appendix H). Material covered within this manual includes information on:

1. Potential hazards associated with radioactive materials
2. Appropriate radiation safety procedures
3. Applicable regulation and license conditions, as well as the location of pertinent regulations, licenses and other material required by regulations
4. Appropriate response to emergencies or unsafe conditions
5. Special in-house rules
6. Individual’s obligation to report unsafe conditions to the RSO and/or applicable authorities
7. Worker’s right to be informed of occupational radiation exposure and bioassay results
New personnel should contact the Radiation Safety Program to obtain the manual and other informational materials before they begin work. Completed exams are to be returned for grading and are retained on file as written verification of worker training. Five or more incorrect answers will require that the exam be retaken.

Individuals required to re-take the exam may meet with the RSO to review the items they missed and clarify any questions the worker may have before they resubmit the exam.

Additionally, Authorized Users shall provide training and instruction to radiation workers regarding specific lab procedures, as well as basic radiation safety issues. The training provided shall be documented on the "Training and Instruction Checklist" (Appendix K). Radiation Workers must complete all three sections of the checklist. Training checklists should be returned to the Radiation Safety Program along with the radiation safety exam where they will be retained for record-keeping purposes.

6.2 Laboratory Workers

Individuals who work in radionuclide laboratories, but will not handle or work with radioactive materials, must also read the manual "Radiation Safety for Laboratory Technicians" prepared by the Radiation Safety Program, and take and pass the associated exam (Appendix H).

Additionally, each Authorized User shall ensure that all persons working in a radionuclide laboratory through the course of their assigned work duties (excluding ancillary personnel) are informed of:

- the storage, transfer or use of radioactive materials within the laboratory and about radiation exposure levels in various sections of the laboratory
- applicable NRC/DHS regulations
- appropriate response to emergency situations within the laboratory area

The training provided shall be documented on the "Training and Instruction Checklist" (Appendix K). Laboratory workers need only complete sections two and three of the checklist. Training checklists should be returned to the Radiation Safety Program along with the radiation safety exam where they will be retained for record-keeping purposes.

6.3 Continuing Education

Continuing education will be provided to radiation workers, lab workers and authorized users through a variety of methods. Newsletters, distributed at least annually, will include information important to the operation of the Radiation Safety Program and the safe handling of radioactive materials. Notices shall routinely be provided to Radiation Workers and Authorized Users providing information on changes in regulations, license conditions, and "lessons learned" experiences from DHS Information Notices and/or situations at other institutions.

Additionally, discussion of changing regulations or the varied regulatory climate and lessons learned from other institutions are included as part of the radiation safety lab audit process.

6.4 Students/Classroom Use
All use of radionuclides in student labs must be carried out under the direct supervision of an Authorized User and/or their trained Radiation Worker. Information on the training requirements for students when radioactive materials are used in the classroom are provided in Section 18.

**Section 7 – Personnel Monitoring**

Authorized Users are responsible for insuring that all persons working for them have and use dosimeters or other personnel monitoring devices when required by NRC/DHS or University regulations.

### 7.1 External Exposure Monitoring

Under the conditions of the UWM DHS license, the use of personnel monitoring devices (e.g. dosimeters) is required for all persons working in radionuclide use areas where they could receive, in a year from external radiation sources, a dose in excess of 10% of the dose limit as outlined in Table 2.

**Table 2. Occupational Dose Limits (in REM)**

<table>
<thead>
<tr>
<th>Area of Exposure</th>
<th>Adult Radiation Worker</th>
<th>Minor Radiation Worker</th>
<th>Embryo/Fetus of Occupational Worker</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yearly Limit</td>
<td>10% of Limit</td>
<td>Yearly Limit</td>
</tr>
<tr>
<td>TEDE(^1) (Whole Body, both external and internal)</td>
<td>5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>CDE(^2) (Organ or Tissue, both external and internal)</td>
<td>50</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Lens of the Eyes</td>
<td>15</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Skin of Whole Body</td>
<td>50</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Extremity</td>
<td>50</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

\(^1\)TEDE is the Total Effective Dose Equivalent as defined in 10 CFR 20

\(^2\)CDE is the Committed Dose Equivalent as defined in 10 CFR 20

Additionally, minors (any person who is under 18 years of age) and declared pregnant workers likely to receive, in a year from external radiation sources, a dose in excess of 10% of the specified dose limits established for these populations (see Table 2) must also be monitored for external exposure.

Two types of dosimeters are issued: “whole body” badges, which measure radiation exposure to the trunk of the body; and “extremity” badges (e.g., ring badges) which measure radiation exposure to hands and/or fingers. Finally, University regulations require that all workers who use 1 mCi or more of
strong beta or gamma emitting radioactive material which decays with certain energies (see Table 3) wear dosimeters to verify that excessive exposure to ionizing radiation has not occurred.

Table 3. Dosimetry Requirements for Strong Beta and Gamma Radiation

<table>
<thead>
<tr>
<th>Radiation</th>
<th>Energy</th>
<th>Dosimeter Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta (β)</td>
<td>&gt;200 keV</td>
<td>Whole Body &amp; Extremity1</td>
</tr>
<tr>
<td>Gamma(γ)</td>
<td>&gt;20 keV</td>
<td>Whole Body &amp; Extremity2</td>
</tr>
</tbody>
</table>

1Unless shielding will prevent extremity exposure
2If operation is such that extremity exposures could not be ascertained from the body badge (e.g., body is shielded)

7.2 Obtaining Dosimeters

Whole body and extremity dosimeters are available from the Radiation Safety Program. To obtain a dosimeter, complete and submit RS Form 310 (Appendix I). All persons requesting dosimeters must have successfully completed the radiation safety exam (see Section 6).

7.3 Lost Dosimeters

If you lose a whole body or extremity dosimeter, contact Radiation Safety Program and submit a “Lost Dosimeter Dose Estimate”, RS Form 320 (Appendix J). If an estimate is not submitted to the Radiation Safety Program, a maximum dose for the monitoring period may be assumed and a $25 replacement fee will be assessed.

7.4 Dosimetry Records and Overexposures

All exposure results are received by the Radiation Safety Officer and are reviewed as soon as they are received from the vendor. You will automatically be notified of any unusual exposure levels. Note, too, that any overexposures will be immediately investigated as required under the campus ALARA program. All personal dosimetry reports for UWM employees and students will be retained indefinitely by the Radiation Safety Program. Individual exposure histories may be obtained from Radiation Safety by submitting a written request. Radiation Safety will provide an annual exposure history to each worker within the first six months of the year following the exposure.

Additionally, federal regulations (10 CFR 20.2104) require that UWM must obtain all available radiation exposure records from your previous employers or institutions where you used radioactive materials. This information is used to evaluate both your current (short-term) and long-term exposure to ionizing radiation. The Radiation Safety Program will request information regarding your previous employers or schools at the time you apply for a dosimeter. If information for the current year is not available a "maximum" dose of 1.25 rem per quarter will be assigned and the allowable dose limit for the year will be reduced by that total.

7.5 Additional Dosimeter Information

Dosimeters provide legal documentation of an individual’s exposure to radiation. Dosimeters issued at UWM are for use involving UWM activities only. All individuals issued a dosimeter to monitor their radiation exposure should follow a few simple rules to insure that the dosimeter accurately records their radiation exposure.
• Wear only your assigned dosimeter; never wear another worker’s badge.
• Wear your ring badge beneath your gloves with the label on the palm side of the hand that handles the radiation source and thus has the greatest potential for exposure.
• Do not store your badge near radiation sources or heat sources.
• If you suspect contamination on your badge, return it immediately to Radiation Safety, and you will be given a new, uncontaminated badge.
• Never intentionally expose your badge to radiation.
• Do not wear your badge when receiving medical radiation exposure (e.g., x-rays, test nuclear medicine procedures, etc.)
• Return your badge to Radiation Safety at the end of the monitoring period. The vendor charges for lost badges and Radiation Safety passes this fee on to the laboratory.

7.6 Internal Exposure Monitoring

When required by 10 CFR 20.1502, each licensee must take suitable and timely measurements of quantities of radionuclides in the body, concentrations of radioactive materials in the air in the work area, or any combination of such measurements as may be necessary for detection and assessment of individual intakes of radioactive material. Specifically, any individual who may receive, in a year, an intake in excess of 10% of the applicable Annual Limits on Intake (ALI) in Table1, Columns 1 and 2, of Appendix B, 10 CFR Part 20, must be monitored for internal exposure. ALI values are based on inhaled or ingested activity that would expose an individual to occupational limits (ICRP 1978). ALI values are measured using bioassay procedures such as urinalysis or thyroid scans. Radioisotope types (alpha, beta or gamma), the potential for exposure, and the amounts of radioactivity received by a laboratory are determinants for scheduling bioassays. For example, workers in a lab receiving a large activity of $^{51}$Cr may not be susceptible to an internal exposure hazard while workers in a lab receiving even small quantities of $^{125}$I may need bioassays.

For radioisotopes other than iodine, routine bioassay measurements shall be required at any time the sum of the total activity of the radionuclide manipulated by the worker in an unsealed form is equal to or exceeds 200 times the ALI for that nuclide. Bioassay monitoring requirements for radioiodine compounds are discussed in Section 14.

Section 8 – Contamination Surveys and Laboratory Monitoring

8.1 User Conducted Monitoring

As with radiation exposure, contamination is undetectable by human senses alone. Laboratory workers must make a deliberate effort to detect contamination by routinely surveying work areas. All users of radioactive materials are responsible for ensuring that adequate area monitoring surveys for radioactive contamination are performed within the laboratory at the end of each day’s work with unsealed sources of radioactive materials. If radioactive materials are in storage (i.e. refrigerator, waste, source bottle, etc.) and are not used on a particular day or series of days, a survey is not required. All surveys must be documented and a copy of the current month’s survey sheet (or a notice detailing where the survey sheet is kept) must be posted in each laboratory.
The area should be surveyed with counting equipment appropriate for the type and energy of radioactive materials being used. If H-3 and/or low levels of C-14 are used, wipe tests must be taken and counted on a gas flow proportional counting system or a liquid scintillation counter. If higher level beta and gamma emitters are used, a survey with a portable GM meter or sodium iodide probe would be adequate. The proper operation of the counting system or meter must be verified with a reference standard or check source prior to counting the survey samples or performing a meter survey.

Any area which has count rates or exposure levels in excess of five times (5X) the background rate is considered contaminated and corrective actions, including decontamination, must be performed. After decontamination is completed the area must be re-surveyed to verify the count rates or exposure levels are below 5X background. Documentation of this result must be provided on the survey sheet.

To be considered adequate, all lab survey documentation must include:

- Location and date of survey
- Diagram of the area surveyed (map)
- Identification of person conducting survey
- Type of survey equipment used (LSC, GM)
- Unit of measure (cpm, dpm, mR/hr)
- Check source or reference source reading
- Background reading
- Measured reading of areas surveyed keyed to locations indicated on survey diagram.
- If contamination is found, documentation as to corrective action taken and results of re-survey of area following corrective action.

8.2 Survey Posting and Recordkeeping Requirements

Examples of proper survey documentation are provided in Appendix M. A copy of the most recent survey or a posting that notes where the current surveys are maintained must be posted in each laboratory. This must be readily visible upon entering the laboratory. Copies of the survey documentation should be retained by the laboratory for a minimum of 3 years and be available for review by radiation safety staff and regulatory inspectors.

8.3 Monitoring Conducted by the Radiation Safety Program

Laboratories or other facilities containing radioactive material will be monitored by the Radiation Safety Program as a spot check to confirm that the contamination control program established by the Authorized User and conducted on a day to day basis by his/her laboratory staff is effective. In laboratories or other areas where >100 mCi of radioactive material in unsealed sources is used, surveys will be conducted weekly. In areas containing < 100 mCi but >200 μCi of radioactive material surveys will be conducted monthly. In areas where < 200 μCi is used or where radioactive materials are in storage only monitoring will be conducted semi-annually.

Wipe tests will be taken to determine the presence of removable contamination from low energy beta emitters. For high energy betas and gammas, Geiger counter surveys will be taken.
in addition to the wipe tests. The wipe tests will be counted on appropriate counting equipment and the results, along with the results of the Geiger surveys, will be tabulated.

Survey records will be kept in the Radiation Safety Program files for at least three years. If contamination is found during a radiation safety monitoring survey, the Authorized User will be contacted and informed as to where the activity is and how to clean it up, or what steps must be taken in order to rectify the situation. In the event of gross contamination, the room will be closed until such time as complete decontamination procedures can be carried out. In such an instance, access to the room will be controlled by radiation safety personnel.

8.4 Final Surveys

If an Authorized User wants to remove a room or area from their authorization or to return a radionuclide laboratory to unrestricted status, RS Form 150 (Appendix D) should be submitted. Arrangements for a final survey of the area can be made by contacting 414-430-7507. Once a final survey is completed and the area shows no residual contamination the laboratory can be declared an unrestricted area and the radiation warning signs removed.

Section 9 – Security of Radioactive Materials

Radioactive materials must be secured against unauthorized removal. All persons working with radioactive materials are responsible for the security of all radioactive materials in their possession including radioactive waste in storage. DHS regulations allow for the use and storage of radioactive materials in several types of areas:

9.1 Restricted Area

A restricted area is any area where access is controlled by the licensee for purposes of protection from radiation and radioactive materials (e.g., secured waste storage vaults).

9.2 Unrestricted Area

An unrestricted area is any area to which access is not controlled by the licensee for the purpose of protection of individuals from exposure to radiation and radioactive materials.

9.3 Controlled Area

A controlled area is any area to which access can be limited for any reason. Radionuclide use laboratories on campus are defined as controlled areas.

9.4 Security

All persons using radioactive materials are responsible for the security of their laboratories and the radioactive materials within those labs. Laboratories in which radioactive materials are used must be locked when unattended. If a worker steps out for even a minute to go to the restroom or even the lab next door, the door must be locked if no one remains in the laboratory.

Radioactive materials stored outside controlled areas must also be secured from unauthorized removal. The regulations permit the storage of radionuclides in locked and labeled refrigerators,
freezers, or cabinets in unrestricted, uncontrolled areas such as hallways or open, general laboratories. The label must read “Caution Radioactive Material” and access to the key must be kept controlled.

Licensed materials in unrestricted and uncontrolled areas, not locked in storage, must be under the constant surveillance and immediate control of a trained Radiation or Laboratory Worker. Any person entering a radionuclide laboratory who is unknown to you or your staff should be challenged as to the reason for their coming into your facility.

Radiation exposure in both controlled and unrestricted areas must be kept below 0.05 mr/hr. Exposure levels must be verified by periodic radiation exposure monitoring.

NOTE: Anyone who suspects that radioactive material has been lost or stolen must contact the Radiation Safety Program immediately.

Section 10 – Food, Beverages, Smoking, etc., in Radionuclide Labs

The following are strictly prohibited in laboratories or other areas where unsealed sources of radioactive materials are present:

- Consumption, preparation and/or storage of food, beverages, or medications
- Application of topical medications or cosmetics
- Smoking and/or chewing of tobacco
- Mouth pipetting

Food and beverage containers CAN NOT be stored in refrigerators, cabinets or desks that are within radionuclide laboratories.

Section 11 – “ALARA” – As Low As Reasonably Achievable

The effects of ionizing radiation on living systems are well defined for relatively high levels of exposure but are rather ill defined for low levels of exposure. The effects of low levels of radiation are the subject of lively debate at present and, in view of the uncertainty involved in describing and quantifying these effects, radiation safety efforts are guided by the conservative philosophy that any exposure may involve some degree of risk. Therefore, all doses should be kept As Low As Reasonably Achievable (ALARA), with economic and social considerations taken into account.

The University of Wisconsin-Milwaukee is committed to maintaining radiation exposures to faculty, staff, students and the public, resulting from the use of radioactive materials and radiation sources in research and teaching, As Low As Reasonably Achievable. As with any safety program, the principle responsibility for worker safety resides with the individual worker. However, all persons involved with radioactive materials and radiation use at UWM have certain responsibilities.
11.1 Radiation Worker

The Radiation Worker should be trained in radiation safety principles, emergency response procedures and the procedures employed by their particular lab. The Radiation Worker shall perform contamination surveys with appropriate equipment after working with radioactive materials. The Radiation Worker must maintain constant control and/or surveillance over radioactivity within their possession.

11.2 Authorized User

The Authorized User is responsible for the safe use of radioactive materials and radiation within their labs and shall insure that their workers perform their assigned radiation safety tasks. The Authorized User is ultimately responsible for the control and security of radioactive materials within their possession.

11.3 Radiation Safety Program

The Radiation Safety Program orders and receives all radioactive material on campus and maintains UWM’s official DHS inventory. Radiation Safety shall conduct basic radiation safety training and training for special uses as necessary. The RSO shall approve all Authorized User actions involving radioactive material use. Radiation Safety manages the radiation dosimetry and pregnancy surveillance programs, conducts dosimetry investigations as necessary and audits each Authorized Users’ program activities semi-annually. Radiation Safety collects and processes all radioactive waste materials generated on campus.

Section 12 – Instrument Requirements for Area Monitoring Surveys

12.1 Portable Survey Meters (e.g. GM)

A reliable, calibrated survey meter must be operating and within the radionuclide laboratory wherever unsealed sources of high energy beta or gamma emitters are being handled. Each laboratory is expected to procure their own meter for this purpose. Each meter must be calibrated to an NIST traceable source at least annually. A free calibration service is offered by the Radiation Safety Program for several types of University owned meters. Meters that cannot be calibrated at UWM must be sent out to a reputable, licensed calibration service. As Authorized Users are responsible for all charges related to off campus calibration of their survey meters, it is highly advisable to consult with the Radiation Safety Program prior to purchasing a meter to ensure it can be calibrated "in house" at no charge. Note, too, that in order to comply with our DHS license conditions all new survey meters must be calibrated to a radiation beam before they can be used in the laboratory. So called "electronic" calibration, which is offered by many vendors, is not acceptable. Therefore, insist on a beam calibrated instrument or arrange with radiation safety for calibration when a new meter is purchased. All new survey meters must be registered with the radiation safety so they can be added to the calibration schedule. Radiation Safety typically calibrates meters in January and July.
Radiation Safety will affix an operational check source to each meter when it is calibrated for the first time. Users of survey meters must verify meter operability with this check source before each use. The check source reading, as well as the background reading, must be documented on the area monitoring survey form every time that a survey is performed.

### 12.2 Liquid Scintillation Counters or Gas Flow Counters

Individuals using low energy beta emitters must have access to a liquid scintillation counter (LSC) or a gas flow counter. Standards for calibrating LSC’s are available, on loan, from the Radiation Safety Program.

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**Section 13 – Contamination and Radiation Levels**

#### 13.1 Removable Contamination

An area is considered to be contaminated when removable radioactivity in excess of 5X background are detected. When contamination is detected, the following procedures should be followed:

- Mark the contaminated area and inform other lab personnel.
- Put on protective clothing, such as rubber gloves, lab coat, etc.
- Clean the area thoroughly with soap and water, count-off, etc.
- Re-monitor the area. If still contaminated, repeat cleaning procedures.
- Document the “clean” survey results.

If the contamination cannot be cleaned, clearly label the area to prevent the spread of contamination and call the Radiation Safety Program for assistance. For spills and contamination problems, or if you are uncertain about how to proceed, contact Radiation Safety immediately.

#### 13.2 Radiation Levels

Radiation levels in the lab must be kept ALARA (see Section 11). Corrective actions must be taken for all areas in which the count or exposure rate from beta and/or gamma or x-ray sources exceeds 5X background levels. This includes areas in which waste or stock solutions are stored.

#### 13.3 Survey Requirements Prior to Repair

If repair or service is to be done on radiation equipment, laboratory fixtures, or physical plant equipment by physical plant workers (plumbers, steamfitters, electricians, etc.) or other individuals without radiation training the following procedures must be followed. Note that the worker must be informed of any potential hazards within the laboratory before the work is begun.

- **Removable Contamination in Work Areas**

  Remove and secure all radioactivity within the area including radioactive waste. Then survey the area or equipment (thorough wipe testing) to be worked on for removable contamination. It must be found “clean” of radioactive contamination before any work
can begin. If contamination is found, the unit or area must be decontaminated, resurveyed, and clearly marked as being free of contamination. All survey results must be documented and a copy provided to physical plant or radiation safety personnel upon request.

- **Radiation Levels in Work Areas**

  Repair personnel may not work in any area where exposures could exceed:
  - 2 mrem in any one hour.
  - 100 mrem per year.

  The Authorized User must retain documentation of these surveys and provide a copy to the worker upon request. In areas not directly assigned to an Authorized User, the Radiation Safety Program will retain the survey records.

**Section 14 – Radionuclide Uses with Special Requirements**

Certain uses of radioactive materials require either special training or additional requirements based on the conditions of our DHS license to reduce personnel exposures and protect workers and/or members of the public from unnecessary radiation exposure. These uses include: radioiodine use, tritium use, airborne radioactivity, and sealed sources of radioactive materials.

14.1 **Radioiodine Use**

Due to the tendency of iodine to concentrate in the thyroid gland, researchers using I-125 or I-131 must take precautions to insure that radioiodine is not inhaled or ingested. Persons performing radioiodinations must receive additional training regarding the properties of radioiodine, observe several iodinations, complete dry runs of the procedure, and obtain a necessary thyroid bioassay before completing iodination activities.

1. **Use of Radioiodine in a Fume Hood or Approved Facility**

   Procedures involving 100 μCi or more of unbound radioiodine or 1.0 mCi or more of non-volatile iodine must be performed in a fume hood or other facility that has been approved by the Radiation Safety Program. Because iodine effluent limits are based on the maximum volume of air exhausted from a hood, these approved radioiodination hoods should run continuously and not be turned off. Notify Radiation Safety if the hood you use needs to be shut down or if you notice the hood is not running.

2. **Thyroid Counts**

   A background thyroid count must be taken within 6 months preceding an individual’s use of 100 μCi or more of volatile or dispersible radioactive iodine or 1.0 mCi or more of radioactive iodine bound to a nonvolatile agent. Persons using these quantities and chemical forms of radioiodine must also have a thyroid count taken within ten days (but not less than 24 hours) of the date on which the iodination was performed. An extension for I-125 bioassays may be granted upon request, but cannot exceed 14 days from the date the material was used.
3. Evaluation of Radioiodine Concentrations in Air

Air monitoring of a radiation worker’s breathing zone is required during each procedure involving 100 μCi or more of volatile radioiodine or 1.0 mCi or more of nonvolatile radioiodine. The steps involved in breathing zone monitoring are as follows:

- An activated charcoal filter will be distributed with the radioiodine order. Additional filters are available upon request.
- Before beginning the procedure, connect the filter to the vacuum line of the calibrated personal exposure level (PEL) pump.
- Turn on the PEL pump and note the time. The pump must run continuously while the iodine procedure is being performed.
- Record the flow rate indicated by the flow meter on the pump.
- After the radioiodine procedure is complete, turn the pump off, note the time elapsed, put the filter in the plastic bag provided and fill in the required information on the label.
- Return the filter to Radiation Safety for analysis.

Monitoring of iodine effluent levels at the rooftop fume hood exhaust point is performed by the Radiation Safety Program.

14.2 Tritium Use

Effluent Releases

Procedures which may produce airborne tritium must be conducted in a fume hood or other approved facility. Some uses may require the Authorized User to provide an adequate system of breathing zone and/or effluent monitoring to assure regulatory levels are not exceeded. Potential releases of volatile H-3 must be assessed. This includes estimation of the concentrations which may be released from the rooftop fume hood vents. The Radiation Safety Program will assist in calculating potential release rates and airborne concentrations.

Monitoring Equipment

All personnel using H-3 must have access to a liquid scintillation counter or gas flow counter in order to assess wipe tests for contamination. Because of its low-energy, H-3 contamination is undetectable with GM or other survey instruments.

14.3 Airborne Radioactivity

Authorized Users having procedures and/or materials which may produce airborne radioactivity (gases, aerosols, or dusts) must perform their operations in a hood or other approved facility. Any radioactive material exhausted or vented to the atmosphere (e.g., ¹⁴CO₂) must be preapproved and reported to the Radiation Safety Program on at least a monthly basis. Contact the Radiation Safety Officer for further information.

14.4 Sealed Sources

A sealed source is any radioactive material that is permanently encapsulated in a sturdy medium which prevents leakage or escape of radioactivity. DHS requires the Radiation Safety Program to keep an inventory of and to perform leak tests on all sealed sources in UWM facilities. If you
receive a sealed or plated source or a piece of equipment containing a sealed source (i.e. gas chromatograph, EC foils, or vacuum gauges), notify us at once so that the source can be inventoried and included in the leak test schedule.

Section 15 – Record Keeping – Inventory

A successful radiation protection program is demonstrated by complete records. These records normally include surveys and inventories.

15.1 Authorized User Record Keeping

The Authorized User is required to maintain up-to-date records of the use, decay, and disposal of the radioactive materials assigned to their laboratory. The Authorized User must implement a viable radionuclide inventory and record keeping method. The user and lab personnel must know where the inventory records are located and how they are used. Authorized Users will:

1. Maintain a log of receipt, use, and disposal of radioactive materials as it occurs. An inventory record sheet (Appendix F) is supplied with each radionuclide delivered which can be used for record keeping purposes. Alternate methods that provide the required information may also be used.
2. Be able to ascertain total activity for each assigned radionuclide at any time. If short-lived nuclides are used, decay must be considered.
3. Keep copies of all supply, disposal, and transfer documentation, and maintain those records for review by regulatory officials for a minimum of three years.

15.2 Radiation Safety Program Record Keeping

The Radiation Safety Program is responsible for maintaining the University’s inventory of radioactive materials, including materials held by each Authorized User and those materials held as waste. Radiation Safety will:

1. Maintain a running inventory for each radionuclide an Authorized User possesses based on receipt and disposal forms provided by the lab and prevent users from exceeding the order and/or possession limits specified within their radionuclide use authorization.
2. Assure that the DHS license limits are not exceeded and that all associated license conditions are met.
3. Check user inventory records during routine lab audits to ensure accuracy. This may involve a physical inventory.

Section 16 – Posting and Labeling Requirements

The Radiation Safety Program will provide laboratories with signs and notices appropriate for each facility.

16.1 Signs and Notices

1. Appropriate "Caution Radioactive Materials" signs will be posted at each entrance to a radionuclide laboratory or radiation facility.
2. Signage indicating “No Eating, Drinking, or Smoking” will also be posted at each facility entrance.

3. The names and telephone numbers of persons who can provide assistance or answer questions regarding radiation safety must be posted.

4. NRC Form 3 and DHS Form, "Notice to the Employees" and the "Notice to Workers", will also be posted in conspicuous locations in each building where radioactivity is used. This notice informs radiation workers and others where copies of the UWM DHS license and related documents may be viewed.

16.2 Container Labeling

Authorized Users are responsible for ensuring the proper labeling of all containers of radioactive materials in their possession, including radioactive waste.

1. For each container of radioactive material, a durable and easily visible label must be affixed clearly identifying the radioactive material contents. The label must contain the radiation symbol, the words "Caution Radioactive Material", the activity of the material, the identity of the radionuclide, and the date for which the activity level was determined.

2. For containers too small to label (e.g., microfuge tubes) the rack or holder may be labeled or the use of the radiation symbol only may be used as the label.

3. A single label may be used to label a group of tubes or vials.

Section 17 – Laboratory Animal Use

Use of radioactive materials in animals must be conducted by or under the direct supervision of an Authorized User who has: (1) submitted an "Animal Use of Radionuclides" form (RS Form 120) to the Radiation Safety Program; and (2) received approval from the UWM Animal Care and Use Committee to follow this protocol. The Authorized User must receive written approval of this request before work can begin. Specific guidelines and training requirements related to laboratory animal use are provided in Appendix Q.

17.1 Responsibilities

The Authorized User is responsible for assuring that:

- Animal rooms and cages are properly labeled to indicate that radioactive materials are being used.
- Animal care personnel are properly trained in the use of radioactive materials.
- Proper safety procedures are followed for the hazard(s) involved.
- Radioactive animals are not moved to unauthorized facilities.

17.2 Preliminary Evaluation

Before work with radioactive material begins, the potential hazard to animal caretakers and other persons entering the animal care area must be evaluated. This evaluation should be based on:

- Radiation dose in the work place
- Excretion of radioactive material
• Special hazards associated with a radionuclide or its chemical form (i.e. volatile iodine, etc.)

17.3 Animal Care Requirements

Animal caretakers must be notified in advance of the need to house radioactive animals. Written procedures for routine animal care and for emergency situations must also be provided to the animal care personnel. The standardized procedures outlined by the Radiation Safety Program should be followed.

17.4 Waste Disposal

Storage space for radioactive animal carcasses is very limited (<20 cubic feet). The Authorized User must make arrangements with the Radiation Safety Officer for waste storage well in advance of any large scale animal work. Proper disposal of animals, bedding, food, and waste is discussed in Section 25.

Section 18 – Use of Radionuclides in Student Labs

The use of radionuclides in student labs must be carried out under the direct supervision of an Authorized User and/or their trained Radiation Worker. Please notify the Radiation Safety Officer prior to using radionuclides in student labs so a safe, successful experiment can be carried out.

18.1 Student Training

The Authorized User is responsible for training students in the safe use and handling of radioactive materials. This instruction need not be lengthy but should include a brief discussion on the basic precautions to take when working with radioactive materials (See Section 18).

18.2 Lab Postings, Surveys, Wastes

The instructional area in which radioactive materials are used must be posted with the signs "Caution Radioactive Materials" and "No Eating, Drinking, or Smoking". Contact the Radiation Safety Program for signs and labels.

Upon completion of radionuclide work all wastes should be properly packaged and disposed of through the Radiation Safety Program. Information on radioactive waste disposal is outlined in Section 25. After all radioactive materials, including wastes, are removed from the area the Authorized User or their designee must complete a survey of the area to ensure that no residual activity remains. The Radiation Safety Program does not normally perform this survey but will provide the Authorized User with the information necessary to complete it. The area must remain posted and maintained as a controlled area until the final survey has been completed. After the area has been found to be "clean", all signs and postings may be removed or covered. If contamination is found, decontaminate the area and re-survey verifying that the area is “clean”. Radiation safety personnel are available to assist, if necessary. All survey results should be documented and maintained for review by regulatory officials.
Section 19 – Radioactive Materials Transportation

When radioactive materials are transported via public routes (i.e. highways, airways, waterways, etc.), rules and regulations promulgated by the Department of Transportation (DOT) apply to protect members of the general public who are not radiation workers from radiation exposure which could result from an accident.

DOT requires any worker who is involved in hazardous materials packaging and transportation to receive initial training, as well as refresher training every 3 years. Most radioactive materials meet the Department of Transportation’s definition of hazardous materials. Therefore, at UWM this training requirement applies to persons who are involved in the transport of radioactive material:

- to and from UWM facilities by motor vehicle (i.e., GLRF/SFS, Field Station)
- to and from remote research facilities
- prepare packages of radioactive material for shipment off-campus

Therefore, Authorized Users or Radiation Workers who package and/or transport radioactive materials must read the manual “Transportation of Radioactive Material” and pass the associated exam. This manual contains information on packaging, labeling, shipping documentation and control of radiation and contamination. Basic guidance is also included on the handling of transport incidents and emergencies during the transport of radioactive materials.

Refresher training will be provided to all certified individuals every three years. Each Authorized User is responsible for insuring that their staff members meet these training requirements if their program involves packaging and/or transporting radioactive materials.

Section 20 – Radiation Safety Program for the Great Lakes WATER Institute/School of Freshwater

All requisitions for radioactive materials to be used at the WATER Institute are forwarded to the Radiation Safety Program on campus for verification of compliance with DHS license conditions and approval. Approved orders are delivered to the Radiation Safety Program in Lapham Hall. After check-in the material will be packaged for transport according to DOT regulations and the WATER Institute laboratory which ordered the radioactive material will be notified that the package is ready for pick up. All individuals transporting radioactive materials must have completed the appropriate training and be certified to do so (See Section 19).

Radionuclide use and radiation safety questions and concerns can be directed to the Radiation Safety Program.

Section 21 – Use of Radioactive Materials aboard UWM Research Vessels

The University has been granted a special condition in its DHS license to use radioactive materials aboard UWM research vessels. When it is necessary for researchers to use radioactive materials on board UWM research vessels, it should be noted that all rules regarding the safe use of radionuclides, as
outlined in this guide, must be followed as well as any additional requirements which may be established by the Radiation Safety Officer or the captain of the vessel.

21.1 Shipboard Use Approval

To use radionuclides aboard research vessels, complete a "Shipboard Use Authorization Form", RS Form 410, (Appendix L) and submit it to Radiation Safety. The original, which must be approved by the Radiation Safety Officer and the Captain of the vessel, will be returned to you. Present the original to the Captain before your cruise. This form serves as: (a) your authorization to use radionuclides aboard the vessel; and (b) your inventory record of the amount of radioactivity you brought aboard the vessel, as required by DHS. The Captain will enter the information in the ship's log for documentation purposes and return the form to you after all radioactivity has been removed from the vessel.

21.2 Security

All radioactive materials used onboard research vessels must be attended by an Authorized User or trained Radiation worker at all times during use. When the materials are not in use they must be stored in a locked/secured container to prevent unauthorized removal or access.

21.3 Area Monitoring Surveys

Routine area monitoring surveys must be performed at the completion of each day's work with radioactive material as outlined in Section 8. Additionally a complete area monitoring survey of the work area for removable contamination must be performed at the completion of each cruise. Copies of those surveys should be forwarded to Radiation Safety where they will be maintained for review by regulatory officials.

21.4 Special Precautions for Shipboard Use of Radionuclides

While performing work aboard research vessels, all researchers must implement the following special safety procedures:

1. Secure all sources of radioactivity against spillage which could arise from movement of the vessel.
2. Use plastic sheeting on the walls and/or floors surrounding the workbench.
3. Use unbreakable containers whenever possible.
4. Use double containment for all sources.
5. Label all work areas, equipment, storage containers, etc. to indicate the presence of radioactive materials.
6. Use absorbent paper and containment trays for all work that has the potential to spill.
7. Use lab coats, disposable gloves, and eye protection.
8. Eating, drinking, and smoking in radionuclide work areas is prohibited. If eating and/or berthing areas are contiguous with lab areas, special working procedures must be arranged in advance and must be approved by the Radiation Safety Officer and the Captain of the vessel.
9. Prepare for spills and have ample decontamination supplies on hand.
10. Undertake frequent monitoring of all work areas to detect, prevent and, if necessary, control the spread of contamination to other areas of the vessel.
11. Carefully package all materials, including waste, for return to the University for further analysis and/or disposal.
12. Perform a thorough area monitoring survey of the vessel after the cruise to insure that NO radioactivity is left behind. Forward a copy of those survey results to Radiation Safety for review.
13. Use extra caution and control to ensure that NO radioactivity is released to the environment.

Appropriate emergency response actions shall be undertaken as necessary. A spill kit shall be available in the work area at all times as well as the phone numbers of individuals (i.e., the RSO) to contact in the event of an emergency.

Section 22 – General Safe Handling Considerations for Radioactive Materials

22.1 Precautions When Working with Unsealed Sources of Radioactive Materials

1. Wear a lab coat, disposable gloves and safety glasses or a face shield. When leaving the lab, remove these items and survey your hands, clothes and work area for radioactive contamination.
2. Cover work areas with plastic backed absorbent material and/or utilize a nonporous tray to contain any spill that may occur.
3. Assume all radioactive material containers are contaminated.
4. Do a "dry run" without radioactive materials to learn or develop new procedures.
5. Radiation Workers should be thoroughly familiar with the properties of the radionuclides they are using. Information sheets on various radionuclides are available from the Radiation Safety Program. If you are uncertain about whether a procedure is safe, please call us for assistance.
6. Employ the three basic rules of radiation safety when working with radioactive materials to maintain exposures As Low As Reasonably Achievable (ALARA): Decrease the time you are exposed to radioactivity, increase the distance between you and the source material, and increase the shielding around the source material.
7. Know the location of your laboratories spill kit and be familiar with campus emergency procedures.

22.2 Some Important Cautions

1. DO avoid working with radioactive materials if you have an open wound.
2. DO use pipette bulbs when pipetting radioactive materials.
3. DO store personal belongings outside the "active" area of the lab.
4. DO leave all food, beverages, or smoking materials outside radionuclide labs.
5. DO remember to wear protective clothing, e.g. disposable gloves, lab coats, eye protection, when handling radioactive material.
6. DO use appropriately labeled sharps boxes for disposal of all syringes, needles, pasteur pipettes, blades and other sharp objects.
Section 23 – Prenatal Radiation Exposure

Since 1906, it has been known that plant and animal cells are most sensitive to radiation damage when they divide rapidly and when they are relatively unspecialized in their function. Thus, the human embryo or fetus is more susceptible to radiation injury than is an adult. It is also known that in the first 8-15 weeks of pregnancy the fetus is most sensitive to radiation. This stage includes the time period in which a woman might be unaware of her pregnancy.

When a woman is pregnant, exposure of her abdomen to sufficiently penetrating radiation from external sources or from internally deposited sources also exposes her unborn baby. As stated above, the unborn is most sensitive to radiation during the first 3 months after conception, the time when a woman may not be aware she is pregnant. Therefore, all Authorized Users and Radiation Workers must read and understand NRC Regulatory Guide 8.13, "Instruction Concerning Prenatal Radiation Exposure" prior to working in a radionuclide laboratory or facility.

23.1 Fetal Protection Policy

Title VII of the Civil Rights Act of 1964, as amended by the Pregnancy Discrimination Act, forbids sex-specific fetal-protection policies. In the 1991 Supreme Court decision involving Johnson Controls the court ruled "It is inappropriate...for individual employers to decide whether a woman's reproductive role is more important to herself and her family than her economic role. Congress has left this choice to the woman as hers to make." The preamble to 10 CFR Part 20 states "It is the fundamental responsibility of the pregnant worker to decide when or whether she will formally declare her condition to her employer...having a woman formally declare her pregnancy to her employer derives from legal, not health protection, considerations."

For those reasons, "special" prenatal exposure limits are applied only to the "declared pregnant woman." It is each woman's choice to formally declare her pregnancy to the University.

23.2 Pregnancy Declaration

Women choosing to declare their pregnancy should contact the Radiation Safety Program. Formal declaration must be made in writing and should include the estimated month of conception. Please note that it is the policy of this office to regard this information as personal and private.

23.3 Exposure Limits for the Embryo or Fetus

The NRC requires that the dose to an embryo or fetus during the entire pregnancy from occupational exposure to radiation to the "declared pregnant woman" (see Sections 23.1 and 23.2) must not exceed 0.5 rem. The regulations also require that substantial variations in the monthly rate of exposure be avoided. Thus, the dose should be incurred at a fairly uniform rate over the entire gestation period and not be incurred in a few large doses. The NRC does permit an additional 0.05 rem of exposure if the pregnant worker has >0.45 rem at the time her pregnancy is declared.
23.4 Monitoring

The dose equivalent to the embryo or fetus should be determined based on the monitoring of the declared pregnant woman. External monitoring should be performed to determine the external dose of the embryo or fetus if the declared pregnant woman is likely to receive a deep-dose equivalent in excess of 50 mRem for the entire gestation period. Monitoring of the intake of radionuclides by the declared pregnant woman should be performed for determining the internal dose to the embryo or fetus if the intake is likely to exceed 1% of the annual limit of intake (ALI) during the gestation period.

Section 24 – Emergency Procedures

24.1 General

In the event of a spill or an emergency involving radioactive material, the immediate objectives are to: (1) render first aid, if necessary; (2) prevent or reduce the chance of personal contamination; (3) prevent dispersal of the contaminant; (4) begin personnel decontamination, if necessary; and (5) decontaminate the area under the supervision of the Radiation Safety Program personnel. All individuals working with radioactive materials should be familiar with these procedures.

24.2 Phone Numbers

- **UWM Police** – 9-911 (from a campus phone)
  414-229-9911 (from a cell phone)

  UWM Police are able to contact Radiation Safety Program staff 24 hours/day.

- **Radiation Safety Program** – 414-430-7507 or 414-229-6339 (business hours)

  Refer to Appendix P for additional emergency numbers.

24.3 Minor Spills and Emergencies

Minor spills and emergencies are those spills of a few microcuries of activity where the radionuclide does not become airborne and emergencies where there is no personal injury. Most minor spills can be handled by lab personnel utilizing the spill kit provided to each laboratory by the Radiation Safety Program. Detailed procedures to follow are:

1. Notify all individuals in the room at once.
2. Limit access to the area to those persons necessary to deal with the spill. Do not let other persons into the area until the spill is decontaminated.
3. Open the lab spill kit and obtain necessary supplies.
4. Confine the spill immediately

**LIQUID SPILLS:**
- Put on protective gloves and clothing.
- Drop absorbent paper or vermiculite on the spill.
**DRY SPILLS:**
Put on protective gloves and clothing.
Dampen area thoroughly, taking care not to spread the contamination.
Generally, water may be used, except where a chemical reaction with the water
could generate an air contaminant or a chemical or physical hazard. Mineral oil
or another predetermined organic solvent should then be used.

5. Notify Radiation Safety of the spill at the first opportunity. If after hours notify campus
police who can contact members of the Radiation Safety Program staff.
6. Survey personnel involved with the spill before they disperse; decontaminate or change
clothes as necessary.
7. Complete a systematic decontamination based on a pre-established plan of action.
8. Submit a written report of the accident to the Radiation Safety Officer. Include a
complete history of the accident, subsequent corrective measures which were taken
and signatures of all individuals involved.

### 24.4 Major Spills and Emergencies

Major spills and emergencies are those spills involving millicurie or greater activity, where
airborne contamination occurs, or personal injury or fire are involved. These situations require
additional assistance and these procedures should be followed:

1. During working hours, notify the Radiation Safety Officer (414-430-7507 or 229-6339) at
once. During holidays, evenings, and weekends, call the UWM Police (9-911 from
campus phones; 414-229-9911 from cell phones, 414-229-4627 from Great Lakes
Research Facility or UWM Field Station). Campus police will contact a member of the
radiation safety staff. Consult the emergency phone list for additional numbers.
2. Remove personnel from the area of the spill and hold them nearby until they can be
checked for contamination by Radiation Safety Program staff.
3. If an individual is injured, apply immediate first aid as necessary. Do not let the
possibility of radioactive contamination hinder first aid efforts. Decontamination of
wounds, etc., can always be done after the victim's medical condition has been
stabilized.
4. If the spill is liquid and the hands are protected, right the container by hand; otherwise,
use tongs, a stick, or similar lever.
5. If the spill is on the skin, flush thoroughly with water and wash with soap or detergent.
6. If the spill is on clothing, remove the article at once and discard it in a plastic bag.
7. Shield the source spill if possible but only if it can be accomplished without further
contamination or without significantly increasing your radiation exposure.
8. If the spill is airborne, evacuate the area at once. Switch off all ventilators and fans.
Physical Plant should be contacted: 229-4742 during business hours or 229-4652 after
hours.
9. Vacate and seal the room and go to a safe area, avoiding additional contamination of
personnel. As practical, take precautions to limit the spread of contamination to other
areas.
10. Take immediate steps to decontaminate personnel involved.
11. Decontaminate the area following a pre-established plan. The RSO or another member
of the Radiation Safety staff will direct the decontamination procedure.
12. Monitor all personnel involved in a spill and cleanup.
13. Submit a written report of the accident to the Radiation Safety Officer. Include a complete history of the accident, as well as corrective measures taken, and signatures of all individuals involved.

24.5 Written Histories and Reports

The following is a guide to preparing histories or reports as required in this section:

1. What happened (i.e. type of accident, cause, how discovered, etc.)?
2. When (time and date)?
3. Where (building, floor, area, etc.)?
4. Who was involved (names and responsible staff members)?
5. Who was exposed to radiation or physically injured (name and extent of exposure or injury)?
6. Damage to facilities (University and non-University)?
7. Is radioactive contamination a problem?
8. What corrective actions were taken?

All individuals involved in the incident should sign the report. Once complete, forward the report to Radiation Safety (Lapham Hall, Room W217) who will review it and process it further, as necessary.

Section 25 – Disposal of Radioactive Materials

25.1 General

The disposal of radionuclides is strictly regulated by federal and state laws and requires careful documentation. The release of radionuclides to the environment is permitted only as outlined in the UWM DHS license. All radionuclides which are no longer in use must be turned over to the Radiation Safety Program for disposal. Only in certain cases, when authorized by the Radiation Safety Officer, can radioactive materials be disposed of otherwise.

Current options for the disposal of low level radioactive wastes are very limited and extremely expensive. Proper waste packaging and labeling will help maximize available disposal options and minimize disposal costs. The following general rules must be followed when collecting and preparing wastes for disposal:

1. Minimize radioactive waste volumes. Keep non-radioactive wastes separate from radioactive wastes, pack waste efficiently and, whenever possible, clean or recycle reusable "wastes" such as glassware or other lab equipment.
2. Keep waste types separate. Do not mix solids, aqueous liquids, organic solvents, LSC wastes, or animal carcasses.
3. To the extent possible, don’t mix radioactivity with other hazardous materials such as hazardous wastes, biohazardous materials (infectious agents), or pyrophorics. Sterilize infectious wastes.
25.2 Transfer of Radioactive Wastes to the Radiation Safety Program

The Authorized User or their representative should contact the Radiation Safety Program when they need to dispose of radioactive wastes. A radioactive waste disposal form (Appendix G) must be completed so the Authorized Users inventory records can be updated. The "copy" (yellow) part of the form should be forwarded to the Radiation Safety Program and the "original" (white) should be filed in the laboratory's radionuclide inventory log. All wastes must be packaged and labeled following the guidelines in this section. Improperly packaged or labeled wastes will not be accepted for disposal until they are properly packaged and appropriately labeled.

Waste Packaging – Solids

- Solid and liquid wastes are handled differently at disposal time, therefore they must be packaged differently. All vials, test tubes, etc., packaged as solid waste MUST NOT contain ANY liquid.
- Solid wastes should be packaged in the plastic bags provided by the Radiation Safety Program. The attached Radioactive Waste Label (Appendix G) must be filled out completely. All labels and radioactive material markings on solid waste material inside the bag MUST be REMOVED or DEFACED.
- Carbon-14 and Tritium wastes are processed similarly and may be packaged together. Wastes from all other isotopes MUST be packaged separately.
- Wastes containing lead are very difficult to dispose of. This includes lead "pigs" or containers, as well as radioactive lead ores. Additional information on the disposal of lead pigs is provided in Section 25.2. Call Radiation Safety for information on the disposal options for radioactive lead ores.
- All needles, syringes, pasteur pipette tips, sharps, blades, etc. must be placed in a sharps container. These containers are provided by the Radiation Safety Program. Once filled, the container should be sealed and disposed of as solid low-level radioactive waste. Report sharps container disposals on the appropriate line of the disposal form.
- Stock solution vials and other source containers should be packaged separately from other solid wastes. Report source vial disposal on the appropriate line of the disposal form.
- Complete a radioactive waste disposal form and contact the Radiation Safety Program to schedule a waste pick up.

Waste Packaging – Liquids

- Liquid wastes should be contained in plastic jugs or carboys furnished by the Radiation Safety Program. When requested, jugs will be delivered during waste pickups. A complete radioactive waste label and a liquid waste tag (Appendix G) MUST be attached to each jug.
- Aqueous wastes MUST be kept separate from organic solvent wastes.
- Neutralize all aqueous liquids: 5.5<pH<8.5.
Waste Packaging – Liquid Scintillation Vials

- Liquid scintillation wastes MUST be kept separate from other wastes. Additionally, LS wastes must be segregated by cocktail type, i.e., sewer disposable or organic hydrocarbon.
- Keep vials separated by size and type (e.g., plastic, glass, film)
- Sewer disposable LS solutions may either be put into aqueous liquid containers (see above) or be kept in their original vials and packaged in boxes for pick up.
- Organic hydrocarbon cocktails (e.g. toluene, xylene, pseudo-cumene based) MUST be kept separate from sewer disposable cocktails. Organic hydrocarbon cocktails must be kept in their original counting vials and packaged in boxes for pick up.
- Affix a completed radioactive waste label to each box. Mark the cocktail brand name and any biological or chemical hazard that might make sewer disposal inappropriate.
- Complete a radioactive waste disposal form and call the Radiation Safety Program to schedule a pickup.

Waste Packaging – Lead Pigs

Do not put lead pigs or source vial containers lined with lead (e.g., NEN gray vial over-packs) in the regular solid waste.

- Meter lead pigs with an appropriate instrument to determine if they are contaminated.
- Package “clean” pigs in a plastic bag or box for pick up with other waste materials. Radiation Safety will process the clean pigs for recycling once they are received.
- If the pigs or containers are contaminated, package them in a labeled waste bag. Identify the nuclide on the label and report the item as “contaminated lead” on the disposal form.
- Complete disposal form as necessary and contact Radiation Safety to schedule a waste pick up.

25.3 Disposal of Radioactive Animal Wastes

All animals which have been injected with or administered radioactive materials MUST be disposed of through Radiation Safety at the end of the project or when sacrificed. When disposing of animal carcasses, tissues, or animal wastes which contain radioactivity, these guidelines should be followed:

- All tissue and carcass wastes should be frozen prior to pick up.
- Place no more than 5.0 mCi of combined total activity of C-14 and H-3 into one container (plastic bag).
- Place no more than 1.0 mCi of any other radionuclide in one container.
- All animal tissues and bedding wastes must be double bagged and tied closed. Disposal bags provided by Radiation Safety should be used. A completed radioactive waste label must be attached to the waste bag. Special notice should be made if biohazardous materials are included in the wastes.
- Blood and urine wastes may be disposed of in the municipal sewer system. These disposals must be reported at least monthly to the Radiation Safety Program (nuclide, activity, and date) on a radioactive waste disposal form.
Complete a radioactive waste disposal form and contact the Radiation Safety Program to schedule a pick up.

25.4 Labeling

Regulations involving the disposal of radioactive and chemical wastes are becoming increasingly restrictive. Complete information must be provided for all wastes to assure that the waste vendor will accept them. A complete radioactive waste label (Appendix G) must be attached to each solid or liquid waste container and liquid scintillation tray or box. Additionally, each liquid waste container must have a completed radioactive liquid waste tag (Appendix G) attached to it. Affix the tag securely to the container.

- Measure or estimate the waste activity. The higher the activity, the more precise the estimate must be.
- Waste activities should be measured whenever possible. Subsample count, correct for efficiency (cpm to dpm), and convert from specific activity (μCi/ml or μCi/g) to total activity (SA * volume).
- Measure and report the pH of all aqueous liquids on the waste tag. List all chemicals and their percentage by volume. The total must equal 100%.
- A completed copy of a radioactive waste disposal form (Appendix G) must accompany all waste to be picked up and disposed of through the Radiation Safety Program. Use a separate line for each bag or container. Keep the ORIGINAL. Tape the COPY to the waste box or container.

**NOTE:** Always report activity as a number with units (e.g., 5.0 mCi). Do not use “trace” or “less than x”. Note other hazardous chemicals including biohazards and toxic materials. To protect waste handlers, **STATE ALL PRECAUTIONS**!

25.5 Radioactive Decay

Disposal of radionuclides by "natural decay" should be reported to the Radiation Safety Program on the bottom section of the Radioactive Waste Disposal Form. Note that we do not automatically calculate losses through decay nor do we automatically remove decayed nuclides from Authorized User inventories. This is to ensure that the amounts of radioactive materials that researchers have "on hand" are not underestimated. It is the responsibility of the Authorized User to provide updated decay information to the Radiation Safety Program. Please call if you have any questions regarding this policy or about calculating the losses through decay of a material.

25.6 Disposal of Radioactive Materials into the Municipal Sewerage System

Disposal of radionuclide wastes into the municipal sewerage system is highly regulated and poses a potential hazard to personnel who service the plumbing in laboratories where radioactive materials are used. In general, the only wastes allowed to "go down the drain" would be those small amounts associated with washing glassware or animal blood and urine wastes. The release of additional wastes down the drain must be approved by the Radiation Safety Officer and appropriate concentration limits must not be exceeded. An accurate
inventory of all radioactive materials released to the sewerage system must be maintained and disposals reported at least monthly on a Radioactive Waste Disposal Form.

25.7 Release of Radioactivity to the Atmosphere

Call Radiation Safety in advance of any procedure which may result in a radioactivity release to the environment. Releases of radioactivity to the atmosphere are permitted only in cases where it would be extremely difficult to contain the activity otherwise. Releases to the atmosphere, which are regulated by the U.S. Environmental Protection Agency (EPA) as well as DHS, should occur only in approved fume hoods, must remain within legal effluent concentration limits and should be accurately inventoried and reported at least monthly to the Radiation Safety Program.

Section 26 – Laboratory Audits and Enforcement

26.1 Laboratory Audits

The Radiation Safety Officer will conduct routine audits of each Authorized User’s program and activities. The frequency of these audits will be based on the activities within the laboratory and the radionuclide laboratory classification. Authorized User programs with type 1 & 2 labs will be audited at least semi-annually and type 3 & 4 labs will be audited at least quarterly. Areas reviewed during audits will include personnel training, monitoring, surveys, record keeping, lab postings, and radiation safety concerns.

26.2 Enforcement

Violations and infractions of University and federal radiation safety regulations can lead to suspension of the UWM DHS license, civil fines, or imprisonment of negligent faculty, staff, students and administrators. The University enforcement policy classifies violations according to the severity of an infraction and its frequency of occurrence. Three classes of violations, which range from "most severe" to "moderately severe" and are summarized as follows:

1. Class A Violation
   Class A Violations are "most severe" and deal with personal injury (actual or potential contamination) to radionuclide users, other UWM personnel, or the general public. Class A Violations can only occur through gross negligence or blatant disregard of DHS regulations.

2. Class B Violation
   Class B Violations are "severe" and focus on personnel overexposure or contamination and the uncontrolled spread of radioactivity.

3. Class C Violations
   Class C Violations are "moderately severe" and focus on significant procedural errors or other administrative issues.
Absorbed dose - The energy imparted to matter by ionizing radiation per unit of mass of irradiated material. The unit of absorbed dose is the rad.

Activity - The number of nuclear disintegrations occurring in a given quantity of material per unit time (see curie).

ALARA - Acronym for the radiation protection philosophy that radiation exposures and effluents to the environment should be maintained "As Low As Reasonably Achievable". The NRC requires that ALARA be considered in the design of all experiments where radioactive material is used.

Alpha Particle - A charged, strongly ionized particle emitted from the nucleus during radioactive decay having a mass and charge equal to a helium nucleus (2 protons and 2 neutrons, and a charge of +2).

Annual Limit of Intake (ALI) - The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year.

Authorized User - An individual member of the teaching or research faculty or staff who has been approved by the University Radiation Safety Officer to use or supervise the use of radioactive material under the conditions specified in an application for authorization. All activities involving radioactive material must be conducted under the authorization of an Authorized User.

Background Radiation - Radiation due to cosmic rays, natural and man-made radionuclides and sources in the environment.

Becquerel (Bq) - SI unit of radioactivity. One Bq equals one nuclear transformation per second. One microcurie is equivalent to 37,000 Bq (37 KBq).

Beta Particle - Charged particle emitted from the nucleus of an atom having a mass and charge equal in magnitude to that of the electron.

Bremsstrahlung - Electromagnetic radiation associated with the deceleration of charged particles passing through matter; "breaking radiation".

Committed Dose Equivalent (CDE) - The sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation.

Committed Effective Dose Equivalent (CEDE) - The sum of the products of the weighing factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Contamination - Deposition of radioactive material in any place where it is not desired, particularly where its presence may be harmful. The harm may be in invalidating an experiment or procedure, or in actually being a source of danger to personnel.

Cosmic Rays - High energy particulate and electromagnetic radiations which originate outside the earth's atmosphere.
Curie - Historic unit of radioactivity. One curie (abbreviated Ci) equals $3.7 \times 10^{10}$ disintegrations per second; a millicurie is equal to one thousandth of a curie (mCi); a microcurie is equal to one millionth of a curie (μCi).

Decay, radioactive - Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

Derived Air Concentration (DAC) - The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an inhalation of one Annual Limit of Intake.

Dose - A general form denoting the quantity of radiation or energy absorbed. For special purposes it must be appropriately qualified, i.e., absorbed dose.

Dosimetry - Measurement or calculation of the amount of energy absorbed in matter.

Effective Dose Equivalent - The sum of the products of the dose equivalent to the organ or tissue and the weighing factors applicable to each of the body organs or tissues that are irradiated.

Electron Volt - A unit of energy equivalent to the energy gained by an electron in passing through a potential difference of one volt, abbreviated eV. Larger units are KeV, for thousand electron volts, and MeV, for million electron volts.

Exposure - A measure of the ionization produced in air by X-rays or gamma radiation. The special unit of exposure is the roentgen (R).

Exposure History - A summary report of radiation exposure of a radiation worker for the term of employment, in terms of the dose equivalent received.

Film Badge - A packet of photographic film used for the approximate measurement of radiation exposure for personnel monitoring purposes. See TLD.

Gamma Ray - Very penetrating electromagnetic radiation of nuclear origin.

Geiger-Mueller (GM) Counter - A portable, gas-filled radiation detection instrument especially adapted for surveying or inspecting an area to establish the existence and estimate the amount of radioactive material present.

Half-life, biological - Time required for the body to eliminate one half of the administered dose of any substance by the regular processes of elimination. Approximately the same for both stable and radioactive isotopes of the same element.

Half-life, effective - Time required for a radioactive element in the body to diminish 50 percent as a result of the combined action of radioactive decay and biological elimination.

Half-life, radioactive - Time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.
Half Value Layer (HVL) - The thickness of a specified material which will reduce the intensity of a given rem of radiation by one half (shielding).

Health Physics - The science devoted to the protection of people and the environment from the harmful effects of radiation.

Inverse Square Law - The intensity of radiation at any distance from a point source varies inversely with the square of that distance.

Ion - Atomic particle, atom, or chemical radical bearing an electric charge, either positive or negative.

Ionization - The process by which a neutral atom or molecule acquires either a negative or positive charge.

Ionizing Radiation - Any electromagnetic or articulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

Isotope - Nuclide having the same number of protons in their nuclei (hence the same atomic number), but differing in the number of neutrons and therefore also the mass number. Almost identical chemical properties exist between isotopes of particular element.

Milliroentgen (mR) - A submultiple of the roentgen, equal to one thousandth of a roentgen.

Nuclear Regulatory Commission (NRC) - Federal agency established by the Atomic Energy Act of 1954 and the Energy Restoration Act of 1974 to regulate the use of radioactive material through its licensing, inspection, enforcement and standards development activities.

Nuclide - A species of atom characterized by the constitution of its nucleus, specified by the number of neutron, protons, and energy content.

Photon - A quantity of electromagnetic energy.

Quality Factor (QF) - A modifying factor by which absorbed doses in rad are multiplied to obtain, for radiation protection purposes, the dose equivalent in rem; a quantity that expresses the biological effectiveness of the absorbed dose on a common scale for all ionizing radiations.

Rad - A measure of the absorbed dose from any ionizing radiation in matter in terms of the energy absorbed per unit mass of the matter. One rad is the dose corresponding to the absorption of 100 ergs per gram of matter and also equals 0.01 Gy (Gray) or 0.01 J/kg. The SI unit for absorbed dose is the Gray (Gy). One Gray is equal to an absorbed dose of 100 rads (1 J/kg).

Rem - The special unit dose equivalent. The dose in rem is numerically equivalent to the dose in rad multiplied by an appropriate modifier.

Roentgen (R) - A unit of exposure to x- or gamma radiation. One roentgen is equivalent to the production of one electrostatic unit of charge of either sign from interactions in 0.001293 gram of air (1 ml of air under standard conditions). 1 R = 2.58 x 10^-4 Coulomb per kilogram (C/kg) of air.
**Survey** - An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

**Thermoluminescent Dosimeter (TLD)** - A solid state device for the measurement of personnel exposure for personnel monitoring purposes. Similar to but more accurate than a film badge.

**Total Effective Dose Equivalent (TEDE)** - The sum of the deep dose equivalent from external sources and the committed effective dose equivalent from internal sources.

**Tritium (³H)** - An isotope of hydrogen having in its nucleus one proton and two neutrons.

**X-Rays** - Penetrating electromagnetic radiation having wave lengths shorter than visible light. Identical to gamma rays except for their extra-nuclear origin.
APPENDICES

A  Form 100-Application for Possession and Use of Radionuclides
B  Form 120-Animal Use of Radionuclides
C  Form 140-Proposed Radionuclide Use Form
D  Form 150-Amendment to Radionuclide Authorization
E  Form 210-Radioactive Material Control Form
F  Form 220-Radionuclide Inventory Form
G  Form 250-Radioactive Waste Disposal Form
    Radioactive Waste Label and Tag
H  Form 300-Radiation Safety Exam
I  Form 310-Personnel Dosimeter Application
J  Form 320-Lost Dosimeter Dose Estimate
K  Form 350-Training and Instruction Checklist
L  Form 410-Authorization to Use Radioactive Materials Aboard UWM Research Vessels
M  Daily Survey Form
N  Form 500-Radionuclide Laboratory Audit Form
O  Form 510-Notice of Radiation Safety Violation
P  Emergency Phone Numbers
Q  Laboratory Animal Use Training Requirements and Safety Guidelines