

**Old Dominion University**

***Radiation Safety Policies and  
Procedures Manual***



**Prepared by:  
Environmental Health & Safety Office  
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**Old Dominion University  
Radiation Safety Policies and Procedures Manual**

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## **Section I.**

### **Introduction**

The Administration of Old Dominion University is committed to maintaining compliance with the applicable provisions of Title 10 of the Code of Federal Regulations and the Commonwealth of Virginia's *Radiation Protection Regulations* (1988). This manual, approved by Old Dominion University's Radiation Safety Committee March of 1999 is a statement of policies, procedures and expectations for all radiation workers, regardless of their status, using radioactive material and radiation producing machines under the University's US Nuclear Regulatory Commission and Commonwealth of Virginia licenses. All University faculty, staff and students using or wishing to use sources of radiation under the University's licenses must be familiar with the requirements of this manual.

Application of the policies and procedures outlined in the Radiation Safety Policies and Procedures Manual is the minimum requirement for maintaining a safe and productive workplace, and keeping radiation exposures as low as reasonably achievable. Any administrative entity at Old Dominion University may impose additional restrictions, qualifications and controls if the imposition of those restrictions, qualifications and controls substantially increases safety and lowers individual and collective doses to workers at reasonable cost.

## Section II.

### User Responsibilities

#### A. *General:*

A chain of responsibility for the safe use of radioactive material and radiation machines exists from individual users to the Radiation Safety Committee. This chain is independent of other administrative lines of control at Old Dominion University; however, the Committee recognizes the right of any administrative entity at the University to impose additional restrictions and qualifications on persons under their supervision for the use of radioactive material and/or radiation producing machines.

#### B. *User Responsibilities:*

Every individual at Old Dominion University that works with radioactive material or radiation producing machines, regardless of his/her user status is responsible for:

1. Reporting promptly to the RSO any condition, resulting from the use of radioactive material or a radiation producing machine, that might lead to an unnecessary or excessive exposure to a worker or member of the general public.
2. Reporting promptly any condition that may lead to or cause a violation of Old Dominion University's US NRC or Commonwealth of Virginia radioactive materials licenses or regulations.
3. Being familiar with the content of Old Dominion University's *Radiation Safety Policy and Procedures Manual*.
4. Keeping exposures to ionizing radiation as low as reasonably achievable (ALARA), see Section VI., page 10.
5. Wearing the prescribed personal monitoring devices (such as whole body and extremity badges) where it has been determined that the individual could receive radiation doses in excess of 10% of the applicable limits (see Section VII., page 15 and Section XX., page 55).
6. Performing precautionary (routine) surveys of areas to determine contamination and dose rate levels (see Section XVIII., page 45).
7. Maintaining records of routine precautionary and "non-routine" surveys (see Section XXIII., page 64).
8. Limiting the use of radionuclides to activities equal to or below the activities authorized by the Radiation Safety Committee, and to the locations specified in the approved experimental protocol.
9. The proper transfer and disposal of radioactive material.

## Section III.

### Authorization Levels

#### A. *General:*

An individual may apply to the Radiation Safety Committee for Authorized or Qualified User status using RSO-1, *Application for Authorized or Qualified User Status: Radioactive Materials*, or RSO-3, *Application for Authorized or Qualified User Status: Radiation Producing Machines* (see Appendices B and C).

Applications must be submitted to the RSO for preliminary review. The RSO then forwards the application to the Radiation Safety Committee Chair. At least three (3) members of the Committee, in addition to the RSO and the Committee Chair, must review the application. Applications will be approved if the Radiation Safety Committee is satisfied that the applicant has adequate training, education and experience to safely carry out the proposed use(s); however, the Committee reserves the right to impose certain restrictions, qualifications and conditions to the approval. All concerns and questions the reviewers have must be addressed and resolved with the applicant before final approval. In lieu of Committee approval, radioactive material and/or radiation producing machines may not be used by the individual except under the direct supervision of an individual with current Authorized User status.

Upon approval by the Radiation Safety Committee, the applicant will be given a copy of the original application, with any additional restrictions, qualifications and/or conditions attached. Status as either an Authorized or Qualified User does not expire; however, if the user requires additional training and/or experience (because of a change in job status or a change in the nature and scope of his/her job), the individual will be required to resubmit the application(s) for approval.

#### B. *Authorized Users:*

A person approved and designated by the Radiation Safety Committee as an "Authorized User" may procure, possess and use radioactive materials and/or radiation producing machines as specified in their approved RSO-1 or RSO-3 (see Section IV., page 6 and Section V., page 8).

In general, Authorized Users must be either faculty or staff at Old Dominion University and ideally would have a position that would allow them to personally supervise the use of the radioactive materials and radiation producing machines under his/her authorization. An Authorized User may sponsor the use of radioactive materials and radiation producing machines by *Qualified Users*. In addition to the responsibilities outlined in Section II. (page 2), Authorized Users are responsible for:

1. The conduct of all personnel using radioactive material and/or radiation producing machines under the conditions of his/her approved protocol.
2. Advising and overseeing persons using radioactive material and/or radiation producing machines under his/her authorization.

3. Maintaining (current) knowledge of the policies and procedures of Old Dominion University's *Radiation Protection Program*.
4. Introductory instruction and direct supervision of persons entering a restricted area under the Authorized User's control.
5. Introductory instruction and direct supervision of persons using radioactive material and/or radiation producing machines who are not specifically authorized by the Radiation Safety Committee.
6. Proper posting of areas where radioactive materials and/or radiation producing machines are used and/or stored (see Section XII., page 27).
7. The security of radioactive material in his/her possession.
8. Instructing employees using radioactive material and/or radiation producing machines under his/her authorization of the actions to be taken in case of emergency.
9. Reporting promptly to the RSO, any accident, incident or emergency involving radioactive material or radiation producing machines (see "Emergency Procedures" preceding the manual.).
10. Maintaining a current inventory of radioactive material in his/her possession, including records of the receipt, disposal and transfer of radioactive material (see Section XV., page 35 and Section XXIII., page 64).
11. Reporting promptly to the RSO, any changes in laboratory personnel including the employment of a minor and the declaration of pregnancy by a worker (see Section VIII., page 17).
12. Submitting amendments to the Radiation Safety Committee prior to any changes in the location(s) of radioactive material and radiation producing machine use, and experimental design (see Section IV., page 6 and Section V., page 8).
13. Maintaining records of inventory, receipt and disposal, and laboratory surveys (see Section XXIII., page 64).

C. *Qualified Users:*

A person approved and designated by the Radiation Safety Committee as an "Qualified User" may use radioactive material or radiation producing machines under the sponsorship of an Authorized User. Qualified Users need not be directly supervised by an Authorized User and cannot authorize the procurement of radioactive material unless the Radiation Safety Committee specifically approves that authority.

Qualified User status is intended for students and technical employees whose backgrounds may not be extensive enough to warrant a broad authorization to bear sole responsibility for the use radioactive materials or radiation producing machines.

D. *Restricted Users:*

A Restricted User is a person who has not applied for, or received approval by the Radiation Safety Committee for either Authorized or Qualified User status. A Restricted User may not use radioactive materials or radiation producing machines, except under direct supervision of an Authorized User.

E. *Visiting Researchers:*

Visiting researchers cannot apply for Authorized User status. They must work under an Authorized User, preferably the faculty member hosting their visit. Visiting researchers may not transfer radioactive material to Old Dominion University without prior approval from the Radiation Safety Committee.

Host faculty must apply for Qualified User status for any visiting researchers working under their authorization at least one month in advance of a proposed visit.

1. In order to be approved for Qualified User status, the visiting researcher must provide the Radiation Safety Committee with proof of prior training and experience working with radioactive material and/or radiation producing machines.
2. The Radiation Safety Office will provide visiting researchers with instruction concerning University policies and procedures.

Old Dominion University will provide dosimetry to visiting researchers as required. The Radiation Safety Office will maintain exposure records and provide a copy of the record to the researcher's facility or organization upon termination of their association with the University. As with all personnel who are monitored for external/internal radiation exposure, a summary of the visiting researcher's exposure for the calendar year in which he or she was monitored will be provided to that researcher as required (see Section XX., page 55 and Section XXI., page 59).

## Section IV.

### Application Procedures for Possession and Use of Radioactive Material

#### A. *General:*

An individual, already approved by the Radiation Safety Committee as an Authorized User, may apply to the Committee to possess and use radioactive material using form RSO-2, *Application for the Possession and Use of Radioactive Materials* (see Appendices B and C). Applications for the possession and use of radioactive material and Authorized User status may also be submitted to the Committee concurrently; however, the applicant will not be approved to possess and use radioactive material without Authorized User status.

#### B. *Initial Applications for Possession and Use of Radioactive Material:*

Radioactive material may not be procured, possessed, stored or used by an individual until the Radiation Safety Committee has approved the applicant's RSO-2.

Applications must be submitted to the RSO for preliminary review. The RSO then forwards the application to the Radiation Safety Committee Chair. At least three (3) members of the Committee, besides the RSO and the Committee Chair, must review the application. All concerns and questions the reviewers have must be addressed and resolved with the applicant before final approval. Applications will be approved if the Committee is satisfied the applicant:

1. Possesses adequate facilities and equipment to ensure the safety of workers, the general public, protect the environment, and to prevent or minimize possible damage to property.
2. Has established safe and effective operating, handling, and emergency procedures.
3. Has designed his/her experiments using radioactive materials such that exposures to radiation will be kept ALARA.
4. Will conform to all applicable policies and procedures established by Old Dominion University's Radiation Safety Committee such as inventory control, radiological surveys, and recordkeeping (see Section XV., page 35, Section XVIII., page 45, and Section XXIII., page 64).
5. Will comply with regulations and procedures established by the US NRC and Commonwealth of Virginia.
6. Has designed his or her experiments such that the generation of radioactive waste is minimized, and no mixed waste is generated.

Upon approval by the Radiation Safety Committee, the applicant will be given a copy of the original application, with any additional restrictions and/or conditions attached. Authorization to possess and use radioactive materials expires two (2) years from the date of final approval.

C. *Authorization Renewal and Amendment Procedures:*

Renewal of the authorization to possess and use radioactive material is obtained by the submission and approval of RSO-6, *Application for Possession and Use of Radioactive Material: Renewal/Amendment* (see Appendices B and C).

Amendments to the original approval, requested prior the expiration date of the original authorization, must be submitted to the Radiation Safety Committee using RSO-6, *Application for Possession and Use of Radioactive Material: Renewal/Amendment*. Actions requiring amendments include:

1. Addition of a radionuclide or radionuclides to the experimental protocol.
2. Change(s) in the form(s) of radiochemical(s) and/or the activity of the approved radionuclide(s).
3. Significant change(s) in the experimental design or the equipment used.
4. Change(s) in location(s) of storage and/or use.
5. Changes in the frequency of routine precautionary surveys, and/or the survey methods.
6. Change(s) in personnel.
7. Change(s) in the list of persons to be contacted in the case of emergency.

## Section V.

### Application Procedures for Possession and Use of Radiation Producing Machines

#### A. *General:*

An individual, already approved by the Radiation Safety Committee as an Authorized User, may apply to the Committee to possess and use radiation producing machines using form RSO-4, *Application for the Possession and Use of Radiation Producing Machines* (see Appendices A and B). Applications for the possession and use of radiation producing machines and Authorized User status may also be submitted to the Committee concurrently; however, the applicant will not be approved to possess and use radiation producing machines without Authorized User status.

#### B. *Initial Applications for Possession and Use of Radiation Producing Machines:*

Radiation producing machines may not be procured, possessed, or used by an individual until the Radiation Safety Committee has approved the applicant's RSO-2.

Applications must be submitted to the RSO for preliminary review. The RSO then forwards the application to the Radiation Safety Committee Chair. At least three (3) members of the Committee, besides the RSO and the Committee Chair, must review the application. All concerns and questions the reviewer have must be addressed and resolved with the applicant before final approval is granted. Applications will be approved if the Radiation Safety Committee is satisfied that the applicant:

1. Possesses adequate facilities and equipment to ensure the safety of workers, the general public.
2. Has established safe and effective operating, and emergency procedures.
3. Has designed his/her experiment(s) using radiation producing machines such that exposures will be kept ALARA.
4. Will conform to all applicable policies and procedures established by Old Dominion University's Radiation Safety Committee.
5. Will comply with regulations and procedures established by the Virginia Department of Health.

Upon approval by the Radiation Safety Committee, the applicant will be given a copy of the original application, with any additional restrictions and/or conditions attached. Authorization to possess and use radiation producing machines expires two (2) years from the date of final approval.

C. *Authorization Renewal and Amendment Procedures:*

Renewal of the authorization to possess and use radiation producing machines is obtained by the submission and approval of RSO-4, *Application for Possession and Use of Radiation Producing Machines* (see Appendices B and C).

Amendments to the original approval, requested prior the expiration date of the original authorization, must be submitted to the Radiation Safety Committee using RSO-4, *Application for Possession and Use of Radiation Producing Machines*. Actions requiring amendments include:

1. Addition of new equipment and/or equipment designed to augment to use of existing equipment.
2. Significant change(s) in the experimental design or ancillary equipment used.
3. Change(s) in location(s) of machine use.
4. Changes in the frequency of routine precautionary surveys, and/or the survey methods (see Section XI., page 23).
5. Change(s) in personnel.
6. Change(s) in the list of persons to be contacted in the case of emergency.

## Section VI.

### The ALARA Program

#### A. *General:*

The Administration of Old Dominion University is committed to keeping individual and collective doses, both occupational and to members of the public, as low as reasonably achievable (ALARA). In accord with this commitment, the Administration will provide the resources necessary to manage an effective *ALARA Program* at the University. The *ALARA Program* describes the policies, procedures, and instructions to foster the ALARA concept at the University. Modifications in existing policies, operating and maintenance procedures, and to equipment and facilities will be considered if the reduction in exposures can be made at justifiable cost to the University.

#### B. *Organization:*

The Radiation Safety Committee administers Old Dominion University's *ALARA Program*. Since judicious delegation of Committee authority is essential to the enforcement of the ALARA concept, the Committee may choose to delegate authority to the RSO to enforce provisions of the *ALARA Program* at the University.

Included in the organization of the *ALARA Program* are those workers for whom the Program is designed and maintained. Radiation workers and ancillary personnel shall be made aware of the Administration's commitment to the ALARA concept and have the opportunity to comment on issues concerning provisions of the *ALARA Program*.

1. Radiation Safety Committee responsibilities:
  - a. Evaluate the resources available to each applicant to ensure that individual and collective doses can be maintained ALARA.
  - b. Review the qualifications of each applicant to ensure that he/she can possess the types and quantities of radioactive material requested while maintaining worker exposures ALARA.
  - c. Review proposed uses of radioactive material to ensure that precautions are taken in the experimental protocol to maintain worker exposures ALARA.
  - d. Review the efforts of the applicant to maintain exposures ALARA when considering new uses of radioactive material and radiation producing machines.
2. Radiation Safety Officer responsibilities:
  - a. Ensure that the contents and implementation of the *ALARA Program* are reviewed at least annually and reported to the Radiation Safety Committee.

- b. Review external radiation doses to workers at least quarterly to determine if individual and collective doses are ALARA.
  - c. Review the results of radiation surveys in unrestricted and restricted areas at least quarterly to determine if dose rates and contamination levels were ALARA.
  - d. Provide training to workers and ancillary personnel including information concerning the University's *ALARA Program* and management efforts to keep exposures ALARA.
  - e. Investigate all known instances of deviation from good ALARA practices and require corrective action(s) be taken to ensure good ALARA practices.
  - f. Implement changes in the *ALARA Program* to maintain individual and collective doses ALARA.
  - g. Establish procedures for receiving and evaluating the suggestions of radiation workers and ancillary personnel for improving radiological health practices and encourage the use of those procedures.
  - h. Be accessible to all users of radioactive material in order to discuss radiation safety, and develop ALARA procedures.
  - i. Communicate worker concerns to the Radiation Safety Committee, and their supervisors
3. Authorized User and Supervisor responsibilities:
- a. Explanation of the ALARA concept to employees, with an emphasis on maintaining exposures ALARA.
  - b. Review of each planned use of radioactive materials to ensure that radiation exposures will be maintained ALARA.
  - c. Ensuring that occupationally exposed workers are trained in good radiological health practices in order to maintain exposures ALARA.

4. Radiation Workers:

Radiation workers will be given opportunities to participate in the formulation of policies and procedures for which they are required to adhere. All radiation workers will be instructed in ALARA concepts and its relationship to their work practices and work conditions. Workers are encouraged and expected to apply those concepts while using sources of radiation to maintain exposures ALARA.

Radiation workers will also be instructed in recourses available to them if they feel that their supervisors, other workers and/or the University's administration are not promoting good ALARA practices.

C. *Delegation of Authority:*

The Radiation Safety Committee may delegate authority to the RSO for maintaining the *ALARA Program*. The Committee shall provide administrative support to the RSO when it is necessary for the RSO to assert authority. If the Committee has overruled the RSO, it will record the basis for its action in the minutes of the quarterly meeting.

D. *ALARA Program Review:*

1. The Radiation Safety Committee will encourage all users to review current procedures and develop new procedures, as appropriate, to implement the ALARA concept.
2. The Radiation Safety Committee will review, at least quarterly, occupational radiation exposures in order to assess trends in occupational exposures. These trends shall be used as an indicator of the *ALARA Program* quality.
3. The Radiation Safety Committee will decide on action(s) to be taken when the University's ALARA exposure limits are exceeded.
4. The Radiation Safety Committee will ensure that an evaluation of the University's efforts for maintaining doses ALARA is performed annually, reviewed, and reported to the Administration.

E. *ALARA Program Investigation Levels:*

Old Dominion University has established investigation levels for occupational external radiation doses which, when exceeded, will initiate review or investigation by the Radiation Safety Committee and/or the RSO. The University's *ALARA Program* investigation levels are listed in Table VI.a (page 13) of this section.

In cases where workers' doses need to exceed an investigation level, a new, higher investigation level may be established by the Radiation Safety Committee for that individual or group on condition that laboratory procedures are consistent with good ALARA practices. Justification for new investigation levels will be presented to the Radiation Safety Committee and documented.

Table VI.a: ALARA Program Investigation Levels for each Department<sup>1</sup>

Department	Exposure Category	Investigation Level (calendar quarter)	
		Level I	Level II
Biology, Chemistry, Computing and Electrical Engineering, Dental Hygiene, Geology, Oceanography & Physics	Whole Body	125 mrem (1.25 mSv)	375 mrem (3.75 mSv)
	Lens of the Eye <sup>3</sup>	375 mrem (3.75 mSv)	1125 mrem (11.25mSv)
	Extremities and Skin <sup>4</sup>	1250 mrem (12.5mSv)	3750 mrem (37.5 mSv)
Nuclear Medicine	Whole Body	325 mrem (3.25 mSv)	500 mrem (5.0 mSv)
	Lens of the Eye <sup>3</sup>	375 mrem (3.75 mSv)	1125 mrem (11.25mSv)
	Extremities and Skin <sup>4</sup>	1250 mrem (12.5mSv)	3750 mrem (37.5 mSv)

<sup>1</sup> Adapted from US NRC Regulatory Guide 10.8, "Guide for the Preparation of Applications for Medical Use Programs," Appendix G, 1987.

<sup>2</sup> Deep dose equivalent (DDE)/Dose equivalent to the whole body, i.e., the head (excluding the lens of the eye), trunk (excluding the male gonads), arms above the elbow, and legs above the knee, taken as the dose at a depth of 1 cm (1000 mg/cm<sup>2</sup>).

<sup>3</sup> Lens dose equivalent (LDE)/Dose equivalent to the lens of the eye at a depth of 0.3 cm (300 mg/cm<sup>2</sup>).

<sup>4</sup> Shallow dose equivalent (SDE)/Dose equivalent to the hands, elbows, arm below the elbow, knee or leg below the knee and skin of the body at a depth of 0.007 cm (7 mg/cm<sup>2</sup>).

F. *Reports of Exposure Less Than Investigation Level I:*

Except when deemed appropriate by the RSO, no action will be taken and no reports made in those cases where an individual's dose is above the minimum detected by the personal monitoring device, but less than the Level I limits.

G. *Reports of Exposures Greater Than Investigation Level I But Less Than Investigation Level II:*

1. The RSO shall report the exposure to the Radiation Safety Committee at the first meeting following the quarter when the dose was recorded.

2. No additional action related to the exposure is required unless deemed appropriate by the Committee.
3. The Committee will review each exposure higher than Level I but less than Level II to compare it with the exposure histories of others performing similar tasks as an index of *ALARA Program* quality. The Committee will record the review in the meeting minutes.

H. *Reports of Exposures Greater Than Investigation Level II:*

1. The RSO shall perform an investigation to determine the cause of the exposure, and, if warranted, will take corrective action.
2. A report of the investigation, any actions taken, and a copy of the individual's Form NRC-5, or its equivalent (see Appendix B), will be presented to the Radiation Safety Committee for review at its first meeting following completion of the investigation. The details of these reports will be included in the Committee minutes.

## Section VII.

### Limits of Exposure to Ionizing Radiation

#### A. *Dose Limits for Radiation Workers:*

All occupationally exposed workers must keep exposures to ionizing radiation as low as reasonably achievable; however no worker, no matter what the circumstances shall be permitted to receive an *annual* dose equivalent to the whole body, any organ(s), or part of the body in excess of the limits listed in Table VII.a:

Table VII.a: Dose Limits for Radiation Workers

Exposure Category	Annual Dose Limit <sup>1</sup>
Whole body <sup>2</sup>	5 rem (0.05 Sv)
Lens of the Eye <sup>3</sup>	15 rem (0.15 Sv)
Extremities and skin <sup>4</sup>	50 rem (0.50 Sv)
Committed dose equivalent and deep dose equivalent to any organ other than the eye <sup>5</sup>	50 rem (0.50 Sv)

<sup>1</sup> From 10 CFR 20.1201

<sup>2</sup> Deep dose equivalent (DDE)/Dose equivalent to the whole body, i.e., the head (excluding the lens of the eye), trunk (excluding the male gonads), arms above the elbow, and legs above the knee, taken as the dose at a depth of 1 cm (1000 mg/cm<sup>2</sup>).

<sup>3</sup> Lens dose equivalent (LDE)/Dose equivalent to the lens of the eye at a depth of 0.3 cm (300 mg/cm<sup>2</sup>).

<sup>4</sup> Shallow dose equivalent (SDE)/Dose equivalent to the hands, elbows, arm below the elbow, knee or leg below the knee and skin of the body at a depth of 0.007 cm (7 mg/cm<sup>2</sup>).

<sup>5</sup> Also *total effective dose equivalent (TEDE)*.

B. *"Special Case" Dose Limits:*

No minor, declared pregnant worker, or individual member of the public shall be permitted to receive a dose equivalent to the whole body, any organ(s), or part of the body or the in excess of the limits listed in Table VII.b:

Table VII.b: "Special Case" Dose Limits

Special Case Exposure Category	Dose Limit
Minors <sup>1</sup>	0.5 rem (5 mSv)
Embryo/fetus <sup>2</sup>	0.5 rem (5 mSv)
Individual member of the public <sup>3</sup>	2 mrem (20 $\mu$ Sv) in any one (1) hour / 100 mrem (1 mSv) annually <sup>4</sup>

<sup>1</sup> From 10 CFR 20.1207, an individual under 18 years of age.

<sup>2</sup> From 10 CFR 20.1208/Worker must declare her pregnancy for this limit to apply (see Section IX., page 27)//Total dose during the entire 9 month gestation period. Taken as the sum of the external dose and internal dose from radionuclides deposited in the mother.

<sup>3</sup> From 10 CFR 20.1301, an individual in a controlled or unrestricted area

<sup>4</sup> From 10 CFR 20.1301, total annual dose excluding doses to members of the public from radioactive waste disposal via sanitary sewage.

## Section VIII.

### Declared Pregnant Worker Policy

#### A. *General:*

Because there is direct evidence that a developing embryo/fetus is especially sensitive to certain radiation effects, pregnant workers should contact the RSO with any questions regarding the risks involved with prenatal radiation exposure. Females of reproductive age should be familiar with the information contained in US NRC Regulatory Guide 8.13 (1987), *Instruction Concerning Prenatal Radiation Exposure* (Appendix F). Additional information and consultation is available through the Radiation Safety Office.

Current 10 CFR 20 dose limits (see Section VIII., Table VII.b, page 16) include limits for the embryo/fetus (or the declared pregnant worker). According to 10 CFR 20, Old Dominion University must ensure that the radiation dose to a developing embryo/fetus (due to occupational exposure of the declared pregnant worker) be kept ALARA, and that under no circumstances shall the occupational dose to the declared pregnant worker exceed 500 mrem (0.5 rem or 5 mSv) during the entire 9-month gestation period. This limit includes both external dose and doses from internally deposited radionuclides. Additionally the University must make reasonable efforts to ensure that any dose to the embryo/fetus does not vary substantially from month to month above a uniform monthly exposure rate (50 mrem/month).

A pregnant employee of Old Dominion University has the *option to declare her pregnancy* for the purposes of her inclusion into the "Embryo/Fetus Radiation Protection Program." Pregnant workers wishing to declare their pregnancy must complete RSO-29, *Declaration of Pregnancy for Inclusion in the ODU Embryo/Fetus Radiation Protection Program* (Appendices A and B) and return the form to the Radiation Safety Office. Inclusion into the program is voluntary and a pregnant worker must declare her pregnancy to be included.

#### B. *Dosimetry Modifications Upon Declaration of Pregnancy:*

Old Dominion University will provide a declared pregnant worker a separate dosimeter (either film or TLD badge), that must be worn on the abdomen (as opposed to the trunk). This dosimeter, which is processed separately from the whole body dosimeter, will monitor and provide a record of external dose to the embryo/fetus. In the event that a worker approaches the designated dose limit, the Radiation Safety Officer has the authority to impose controls to further limit radiation exposure to the embryo/fetus. Minimum modifications to the dosimetry program and administrative controls for a declared pregnant worker include:

1. Keeping embryo/fetus dose as low as reasonably achievable (ALARA) during the pregnancy and limiting the embryo/fetus dose to 500 mrem (0.5 rem or 5 mSv) during the entire 9-month gestation period.
2. Ensuring that doses received (if any) do not vary substantially from month to month above a uniform rate, i.e., 50 mrem.

C. *Declared Pregnant Worker Responsibilities:*

Declared pregnant workers are responsible for:

1. Keeping exposure(s) to radiation ALARA by employing good radiological health practices.
2. Reporting promptly a suspected or known intake of radioactive material.
3. Wearing the assigned external radiation monitors and reporting promptly any suspected external exposure that differs substantially from previous months.

## Section IX.

### **Human Use of Radioactive Material**

Old Dominion University does have a license that allows for *in vivo* use of radioactive material in humans, whether for diagnosis or therapy. Also, external irradiation of humans with byproduct or accelerator produced radioactive material or radiation producing machines for research or investigative purposes (as opposed to the healing arts) is prohibited.

*In vitro* laboratory procedures and assays using biological materials of human origin, e.g., diagnostic RIA kits, etc., are not considered to be human use.

## **Section X.**

### **Laboratory Rules and Procedures to Ensure the Safe Use of Radioactive Material**

#### **A.     *General:***

The safe use of radioactive material in the laboratory depends on workers and supervisors adhering to generally accepted procedures, the pre-approved conditions of the radioactive materials use authorization and to policies and procedures adopted by the Radiation Safety Committee.

#### **B.     *Prior to Radioactive Material Use:***

1.     The Authorized User must ensure that radiation workers under his/her direct supervision have received adequate instructions, as specified in 10 CFR 19 (see Appendix D). The extent of instruction must be commensurate with the potential radiological health problems posed by the use of the radioactive material.
2.     The Authorized User must discuss the scope of the employee's work, any necessary safety precautions, and emergency procedures to be followed in case of an accidental exposure or spill.
3.     Standard operating procedures for each task that involves the use of radioactive material must be made available to all personnel using radioactive material. The degree of detail in the written procedure(s) must be commensurate with the potential hazards of procedure(s).
4.     The Authorized User must familiarize new employees with laboratory procedures involving radioactive material by first performing the experiment(s) using non-radioactive products.
5.     The Authorized User must ensure that the laboratory has a sufficient quantity of personnel protective equipment, e.g., gloves, lab coats, and safety goggles, etc., for all employees involved with the use of radioactive material.
6.     The laboratory or storage area and areas within a laboratory or storage area where radioactive material is present must be properly labeled or otherwise delineated.
7.     A sink for the cleaning contaminated glassware and other labware must be designated and labeled. The drain trap and/or exposed plumbing of the designated sink must also be labeled to warn maintenance personnel.

8. The Authorized User must ensure that the laboratory has an adequate supply of equipment consistent with the nature of the work and commensurate with the potential radiological hazard(s), for example:
  - a. Survey and counting instruments.
  - b. Remote handling equipment and automatic pipettes.
  - c. Absorbent, plastic backed paper.
  - d. Waste containers.
  - e. Trays and other containment devices.
9. The Authorized User must ensure that workers have personal dosimetry devices available that are appropriate for monitoring the type(s) of radiation present.

C. *General Laboratory Procedures:*

1. High standards of cleanliness and good housekeeping are expected in all laboratories where radioactive material is used and/or stored.
2. Do not eat, drink, smoke or apply cosmetics in any area where licensed material is stored or used.
3. Do not store food and drinking areas where licensed material is stored or used.
4. Radioactive materials must be used and stored in such a manner as to restrict unauthorized persons from using or removing such materials. *Restricted Areas* must be secured when not attended by qualified personnel.
5. The use disposable laboratory supplies wherever and whenever possible is recommended to lessen the spread of contamination.
6. Individuals must wear protective eyewear when working with radioactive materials.
7. Laboratory personnel must wear lab coats to protect clothing, and gloves to protect skin when working with radioactive materials.
8. To avoid spread of contamination, laboratory personnel should change gloves frequently and remove used gloves in the work area. Faucets, light switches, doorknobs, telephones, etc. should not be handled with gloves.
9. Procedures involving gaseous, volatile or dust-forming radioactive material must be confined to fume hoods or glove boxes, if appropriate.

10. Mouth pipetting is prohibited. Mechanical pipettes and automatic dispensers are recommended and should be used whenever possible.
11. Persons who are designated to wear personal monitoring devices (film badges, TLD's, pocket dosimeters, etc.) by the Radiation Safety Office must wear such devices at all times when they work with or near radioactive material for which the devices are appropriate.
12. Storage and waste containers must be clearly labeled and shielded (as required and as practical) to prevent unnecessary radiation exposure.

## Section XI.

### **Training, Controls and Operating Procedures to Ensure the Safe Use of Analytical X-Ray Systems**

#### A. *General:*

The Virginia Department of Health, Bureau of Radiological Health, the agency responsible for the regulation of radiation producing machines defines an *analytical x-ray system* as "a group of components utilizing x-rays to determine the elemental composition or to examine the microstructure of materials."

The regulatory requirements for analytical x-ray systems are found in Part IX of the Commonwealth of Virginia's *Radiation Protection Regulations*, "Radiation Safety Requirements for Analytical X-Ray Equipment."

Individual must apply for and receive approval from the Radiation Safety Committee as either Authorized or Qualified User prior to operating an analytical x-ray system (see Section V., page 8).

#### B. *Training Requirements:*

Section 9.6 (paragraph A, "Instruction"), Part IX of the Commonwealth of Virginia's *Radiation Protection Regulations* outlines the training requirements for users of analytical x-ray systems. Specific instructions include:

1. Identification of radiation hazards associated with the use of the [x-ray] equipment.
2. Significance of the various radiation warning and safety devices incorporated into the [x-ray] equipment.
3. Proper operating procedures for the [x-ray] equipment.
4. The symptoms of acute localized exposure.
5. Proper procedures for reporting an actual or suspected exposure.

#### C. *Controls and Operating Procedures for Analytical X-Ray Systems:*

1. Warning and safety devices:
  - a. A warning light with the words "X – RAY ON" must be located near any switch that energizes the X-ray tube.
  - b. The warning light must have "fail-safe" characteristics, i.e., the system will not operate if the warning light malfunctions.

2. Warning labels:
  - a. “CAUTION – HIGH INTENSITY X-RAY BEAM” must be posted on the x-ray source housing.
  - b. “CAUTION – THIS EQUIPMENT PRODUCES X-RAYS WHEN ENERGIZED” must be posted near any switch that energizes the x-ray tube.
3. Interlocks and x-ray source housing and ports:
  - a. Interlocks that turn off the x-ray beam if the housing is removed, or the housing is disassembled must be provided.
  - b. The source housing must be constructed such that with all shutters closed, the radiation level at a distance of 5 cm from the surface of the housing does not exceed 0.25 mrem in one hour.
  - c. Unused ports in the source housing must be secured in the closed position such that it will prevent casual opening.
3. During the performance of routine repairs, maintenance and modifications, the main switch, not the interlock system must be used shut down the system until restoration of safe conditions.
4. Operating procedures:
  - a. Standard operating procedures (SOP’s) must be written and available to all analytical x-ray system operators.
  - b. No person shall be permitted to operate an analytical x-ray system in any manner other than that specified in the SOP’s unless approval has been obtained from the Radiation Safety Committee.
  - c. No operator shall bypass a safety device, (e.g. housing interlocks) unless approval has been obtained from the Radiation Safety Officer. If approval to bypass a safety interlock has been granted, the following restrictions (as a minimum) apply:
    - (1) The approval to bypass a safety device shall be for a specified time.
    - (2) If the safety device has been bypassed, a sign reading “SAFETY DEVICE NOT WORKING” or another with similar intent shall be placed on the housing in plain view.

D. *Personal Monitoring:*

Personal monitoring devices will be issued to persons operating analytical x-ray systems if they are likely to receive radiation doses in excess of the limits listed in Tables XI.a and XI.b:

Table XI.a: Quarterly Dose Requiring Personal Monitoring

	Quarterly Dose Requiring Monitoring <sup>1</sup>
Whole Body <sup>2</sup>	0.125 rem (1.25 mSv)
Lens of the Eye <sup>3</sup>	0.375 rem (3.75 mSv)
Extremities and Skin <sup>4</sup>	1.25 rem (12.5 mSv)
Sum of the Deep Dose Equivalent and Committed Dose Equivalent to Any Organ Other than the Eye	1.25 rem (12.5 mSv)

<sup>1</sup> From the Commonwealth of Virginia's *Radiation Protection Regulations* (1987), § 5.101. The 10% requirement adopted by Old Dominion University, 1999.

<sup>2</sup> Deep dose equivalent (DDE)/Dose at a depth of 1.0 cm (1000 mg/cm<sup>2</sup>).

<sup>3</sup> Lens dose equivalent (LDE)/Dose at a depth of 0.3 cm (300 mg/cm<sup>2</sup>).

<sup>4</sup> Shallow dose equivalent (SDE)/Dose at a depth of 0.007 cm (7 mg/cm<sup>2</sup>).

Table XI.b: Special Case Monitoring Requirements

	Quarterly Dose Requiring Monitoring <sup>1</sup>
Minors <sup>2</sup>	
a. Whole body (DDE)	12.5 mrem (0.125 mSv)
b. Lens of the eye (LDE)	37.5 mrem (0.375 mSv)
c. Extremities and skin (SDE)	125 mrem (1.25 mSv)
d. Sum of the deep dose equivalent and the committed dose equivalent to any organ other than the eye	125 mrem (1.25 mSv)
Embryo/fetus (declared pregnancy)	50 mrem (0.5 mSv) <sup>3</sup>

<sup>1</sup> Adopted by Old Dominion University's Radiation Safety Committee (1999).

<sup>2</sup> Individuals under 18 years of age.

<sup>3</sup> Worker must declare her pregnancy for this limit to apply (see Section VIII., page 17)/Total dose during the entire 9 month gestation period. Taken as the sum of the external dose and internal dose from radionuclides deposited internally in the mother.

E. *Area Requirements:*

Analytical x-ray systems must be located and arranged and must include sufficient shielding and access control such that radiation levels in any area surrounding the systems do not exceed the radiation dose rate limits listed in Table XI.c:

Table XI.c: Dose Rate Limits for Areas

Condition	Dose Rate Limit <sup>1</sup>
Individual continuously present in area	< 2.0 mrem in any one hour
Individual continuously present in area	< 100 mrem in any 7 consecutive days

<sup>1</sup> From the Commonwealth of Virginia's *Radiation Protection Regulations* (1987), § 5.105.

F. *Surveys:*

Surveys of analytical x-ray systems must be conducted to demonstrate compliance with the area dose rate limits listed in Table XI.c (above). Specifically surveys must be performed:

1. Upon installation of the system and *at least once every 12 months thereafter*.
2. Following any change in the initial arrangement, number and type of local components in the system.
3. Following any maintenance requiring disassembly or removal of a local component in the system.
4. During maintenance and alignment procedures if the procedure(s) require that the primary beam is on, and local components are either disassembled or removed.
5. Any time a visual inspection reveals an abnormal condition.
6. Whenever personal monitoring devices show a significant increase in the dose received by operators of the system.

## Section XII.

### Marking and Labeling

#### A. *General:*

Rooms, areas, and equipment where radioactive materials are used and/or stored must be clearly marked with appropriately worded signs and/or labels. Action levels for labeling are summarized in Table XII.a:

Table XII.a: Summary of Required Labeling <sup>1</sup>

Sign or Label	Action Level for Posting of Signs
"Caution, Radioactive Material(s)"	> 10 times activity in 10 CFR 20, Appendix C, used and/or stored in an area
"Caution, Radiation Area"	Individual(s) in area could receive a dose equivalent > 5 mrem in any 1 hour/30 cm from the source(s) of radiation
"Caution, High Radiation Area"	Individual(s) in area could receive a dose equivalent > 100 mrem in any 1 hour/30 cm from the source(s) of radiation
"Caution, Airborne Radioactivity Area"	Airborne concentration exceeds DAC/1 week intake $\geq 0.6\%$ of ALI (or 12 DAC hours)

<sup>1</sup> From 10 CFR 20.1902.

#### B. "*Caution, Radioactive Material(s)*" or "*Danger, Radioactive Material(s)*":

1. Areas or laboratories in which radioactive materials are used and/or stored in quantities greater than 10 times the quantity specified in Appendix C to 10 CFR 20 (see Appendix D), must be posted with a sign or signs bearing the radiation symbol and the words "*Caution, Radioactive Material(s)*," or "*Danger, Radioactive Materials.*" Areas requiring such signs are designated *Restricted Areas* for the purposes of restricting access to qualified individuals only.
2. Containers in which radioactive material is stored must be labeled with the radiation symbol, the words "*Caution, Radioactive Material*" or "*Danger, Radioactive Material.*" An additional label with the following information must also be affixed to the container:
  - a. The radionuclide.
  - b. The activity (in units or subunits of Ci, Bq or dpm) and date.

3. Labeling is recommended, but not required for containers used for the transfer of radioactive material provided the user immediately decontaminates the containers.
4. After surveys are performed to confirm that contamination levels are acceptable for release of an area or equipment as unrestricted (see Section XVIII, Table XVIII.f, page 51) radiation warning signs and labels must be removed and/or obliterated.

C. “*Caution, Radiation Area*” or “*Danger, Radiation Area*”:

Areas accessible to individuals, in which radiation levels could result in those individuals receiving a dose equivalent in excess of 5 mrem in 1 hour at a distance of 30 centimeters from a radiation source or from any surface from which the radiation penetrates must be posted with a sign or signs bearing the radiation symbol and the words “*Caution, Radiation Area,*” or “*Danger, Radiation Area.*”

D. “*Caution, High Radiation Area*” or “*Danger, High Radiation Area*”:

Areas accessible to individuals, in which radiation levels could result in those individuals receiving a dose equivalent in excess of 100 mrem in 1 hour at a distance of 30 centimeters from the radiation source or from any surface from which the radiation penetrates must be posted with a sign or signs bearing the radiation symbol and the words “*Caution, High Radiation Area,*” or “*Danger, High Radiation Area.*”

E. “*Caution, Airborne Radioactivity Area*”:

A sign or signs bearing the radiation symbol and the words “*Caution, Airborne Radioactivity Area,*” or “*Danger, Airborne Radioactivity Area*” must be posted at the entrance(s) to rooms, or enclosed spaces in which airborne radioactivity, composed totally or partially of licensed radioactive material is present:

1. In concentrations exceeding the *derived air concentrations* (DAC’s), found in Appendix B of 10 CFR 20, for the radionuclide(s) present.
2. In concentrations such that an individual, without respiratory protection, present in the area could receive in a week, an intake of radioactive materials  $\geq 0.6\%$  of the *annual limit on uptake* (ALI), or 12 DAC hours.

F. *Clean Areas*:

Areas within *Restricted Areas* where eating, drinking and/or the application of cosmetics are approved must be designated as *Clean Areas*. As a rule the designation of such areas is discouraged, and the Radiation Safety Officer, only under extraordinary circumstances, will grant approval where no other acceptable alternative exists. Under no circumstances shall the Radiation Safety Officer approve a Clean Area if there is the potential for airborne radioactive material in the laboratory.

Clean Area(s) must be clearly delineated with tape, and signs or labels bearing the words "*Clean Area – No Radioactive Material*" or equivalent. General requirements for a clean area:

1. Clean Areas must be located such that no radioactive materials will be transported through the area at any time.
2. At no time shall radioactive materials or potentially contaminated equipment be stored or used in a Clean Area.

G. *Building Fixtures and Mechanical Equipment:*

Building fixtures such as drain traps, and mechanical equipment such as fume hood blowers, fans and ducting, with a reasonable potential for radioactive contamination, must be clearly labeled with the words *Caution Radioactive Materials* and a warning message such as "*Contact the Radiation Safety Office before disassembly or repair*" (or equivalent).

## Section XIII.

### Animal Use Procedures

#### A. *General:*

Experiments involving animals and radioactive materials must be approved by the Radiation Safety Committee and the Animal Care and Use Committee. No animal containing radioactive material may be transferred off-campus without the approval of the Animal Care and Use Committee and the Radiation Safety Officer.

#### B. *Authorized User Responsibilities:*

1. Authorized Users are responsible for the proper labeling of areas housing radioactive animals including the cages in which the animals are housed:
  - a. The room must have a sign or label at the entrance bearing the words "Caution, Radioactive Material."
  - b. The Authorized User must also post written instructions for animal caretakers *on or near* the cage(s). Instructions must include precautionary procedures for animal handling and procedures for the care of ill or dead animals.
2. Authorized Users must ensure that animal excreta and bedding contaminated with radioactive material is contained within the designated animal housing.
3. Authorized Users are responsible for radioactive animal carcasses, including proper labeling, storage and disposal (see Section XII., page 27, and Section XVII., page 38).
4. In cases when caging requires specialized cleaning and/or decontamination, the Authorized User will be responsible. Contamination levels must be at or below the levels specified in Section XVIII., Table XVIII.f, page 51.
5. Authorized Users are responsible for the security of the designated restricted area. Rooms in which radioactive animals are housed must be locked or otherwise secured when left unattended by the Authorized User or qualified animal caretaker(s).

#### C. *Animal Caretaker Responsibilities:*

1. Animal caretakers are responsible for following the Authorized User's written instructions regarding the care of the animals as well as for the care of ill and dead animals. Identifying warning labels and tags must not be removed until it has been confirmed that contamination levels on cage surfaces are at or below the levels specified in Section XVIII., Table XVIII.f, page 51.

2. Animal caretakers must wear personal protective equipment, e.g., gloves, lab coats, etc., and dosimetry (if deemed necessary by the RSO), at all times when handling radioactive animals.
3. Animal caretakers are responsible for disposing of absorbent paper and bedding, urine, feces, and other waste in properly labeled containers (provided by the Authorized User through the Radiation Safety Office).
4. Animal caretakers are responsible for promptly reporting (to the Authorized User and the Radiation Safety Officer) any condition or event that might lead to a violation the conditions of Old Dominion University's US NRC or Commonwealth of Virginia licenses.

## Section XIV.

### Procurement of Radioactive Materials

#### A. *General:*

All orders for radioactive material must originate with an Authorized User. Depending on the source of funds, orders should be placed using either a standard Commonwealth of Virginia Purchase Requisition, a Old Dominion University Research Foundation (ODURF) Requisition or an Old Dominion University Research Foundation Limited Purchase Order. Commonwealth of Virginia Limited Purchase Orders *may not* be used to procure radioactive material.

#### B. *Radioactive Material Purchase:*

Each Commonwealth of Virginia or ODURF Purchase Requisition or ODURF Limited Purchase Order must be approved and signed by the Radiation Safety Officer prior to ordering radioactive material. Approved orders will be forwarded to the appropriate agency once the approval has been obtained. Orders will not be placed until RSO approval has been granted.

Requisitions or purchase orders must include the following information:

1. The radionuclide being ordered.
2. The chemical form of the radiolabeled product.
3. The activity of the material.
4. The catalog number of the product.
5. Any special instructions, e.g., rush order, etc.

In the body of the requisition or purchase order the statement "Radioactive Material for ...(name of the Authorized User)" should appear.

*The delivery address for all radioactive material is:*

Old Dominion University  
Environmental Health and Safety Office  
5255 Hampton Blvd, Spong Hall suite 203  
Norfolk, Virginia 23529  
Attn.: Radiation Safety Officer

Deliveries of radioactive material directly to the Authorized User or to locations other than the Environmental Health and Safety Office are prohibited. Deliveries to Public Safety, at any time, will be refused.

C. *Radioactive Materials Receipt:*

Upon receipt of radioactive material, Radiation Safety Office personnel will follow Standard Operating Procedures so as to fulfill the requirements of 10 CFR 20.1906. All packages with evidence of damage, i.e., crushed, wet or punctured packages, must be monitored for removable contamination on the package surface and radiation levels (if applicable). Maximum permissible removable contamination levels are listed in Table XIV.a:

Table XIV.a: Maximum "Permissible" Package Contamination Limits

Radionuclide	Maximum "permissible" contamination limit <sup>1</sup>
Beta-gamma emitting radionuclides, and all radionuclides with half-lives less than 10 days	22 dpm/cm <sup>2</sup> (10 <sup>-5</sup> μCi/cm <sup>2</sup> )
All other alpha emitting radionuclides	2.2 dpm/cm <sup>2</sup> (10 <sup>-6</sup> μCi/cm <sup>2</sup> )

<sup>1</sup> From 49 CFR 173.443, Table 11, as determined by wiping a 300 cm<sup>2</sup> area of the package surface and averaging the removable contamination levels over the entire surface area wiped.

1. Packages containing excepted, limited quantities, of radioactive material.

Excepted packages of limited quantities of radioactive material do not require radiation labels on the outside of a package. Quantities below values (defined in 49 CFR 173.421 and specified in 49 CFR 173.435 Table of A<sub>1</sub> and A<sub>2</sub> values for radionuclides) are considered "excepted, limited quantity."

- a. Packages will be opened and the contents examined to ensure that the material delivered and ordered, agree, and that there is no damage to the source vial(s).
- b. Packages that show evidence of damage will be monitored for removable contamination and external radiation levels.

Receipt of the package and the results of surveys (if necessary) will be recorded on RSO-5, *Radioactive Materials Receipt and Delivery Record* (see Appendices B and C).

2. Labeled packages:

External surfaces of packages must be labeled if they contain quantities of material greater than Type A values (Appendix A of 10 CFR 71). Labeled packages must be surveyed for removable contamination and monitored for external radiation levels. The required survey and monitoring must be performed within 3 hours of package receipt. External radiation limits for labeled packages are listed in Table XIV.b:

Table XIV.b.: External Radiation Limits for Labeled Packages

Type Label	External Radiation Limit <sup>1</sup>	
	Package Surface	
Radioactive White I <sup>2</sup>	< 0.5 mrem/hr.	0.5 mrem/hr.
Radioactive Yellow II <sup>3</sup>	> 0.5 mrem/hr. but < 50 mrem/hr.	
Radioactive Yellow III <sup>4</sup>	> 50.0 mrem/hr. but < 200 mrem/hr.	

<sup>1</sup> From 49 CFR 172.403

<sup>2</sup> From 49 CFR 172.436

<sup>3</sup> From 49 CFR 172.438

<sup>4</sup> From 49 CFR 172.440

The Radiation Safety Office will notify the final delivery carrier and US NRC if:

- a. Removable contamination levels on the external surface of the package exceed the limits listed in Table XIV.a (page 33) of this section.
- b. Package external radiation levels exceed those limits listed in Table XIV.b (above) of this section.

D. *Radioactive Materials Delivery:*

After receipt and survey (if necessary) the Radiation Safety Office will deliver radioactive material to the Authorized User. Two forms accompany the material: RSO-5, *Radioactive Materials Receipt and Delivery Record* and RSO-24, *Radioactive Material Use and Disposal Log* (see Appendix B and C). Package delivery procedures:

1. An Authorized or Qualified User must be present to accept the material and sign RSO-5, *Radioactive Materials Receipt and Delivery Record*. Restricted Users and other laboratory personnel who have not been approved by the Radiation Safety Committee as either an Authorized or Qualified User may not sign for, or receive radioactive material.
2. Radioactive material will not be delivered and/or left in an unrestricted area, e.g., an office, Clean Area, etc..
3. Radiation Safety Office personnel will require that the package be inspected by the recipient to ensure that the package contents and packing list agree.

Packaging material must be surveyed by an Authorized or Qualified User, and any radiation labels defaced or destroyed before the packaging is disposed in regular trash.

## Section XV.

### Inventory Control

#### A. *General:*

Radioactive material inventories are controlled and verified by the Radiation Safety Office. Authorized User inventories are verified prior to ordering radioactive material to insure that the User's approval limits and the University's license limits are not exceeded.

#### B. *Authorized User Responsibilities:*

Authorized Users are required to maintain a current inventory of radioactive material in their possession. The current inventory must account for all radioactive material including:

1. Stock material (diluted and undiluted).
2. All waste in the laboratory.
3. Archived samples and scintillation vials.

Upon delivery of radioactive material, Users are given a copy of RSO-24, *Radioactive Materials Use and Disposal Log* (see Appendices B and C). This form may be used to account for radioactive material in the laboratory; however, Authorized Users may create and use any equivalent form, or database to track the use and disposal of radioactive material in their possession.

#### C. *Radiation Safety Office Responsibilities:*

The Radiation Safety Office maintains current inventories for all Authorized Users. In addition to the current inventories, the Radiation Safety Office requires all Authorized Users to perform a physical inventory of radioactive material in their laboratories no less than every 6 months (at the end of February and the end of August). Authorized Users are required to submit a completed RSO-8, *Semi-Annual Radioactive Materials Inventory* (see Appendices B and C) to the Radiation Safety Office. The results of physical inventories conducted by Authorized Users are used to verify inventories maintained by the Radiation Safety Office, and to demonstrate compliance with the University's stated license limits.

## Section XVI.

### Transfer of Radioactive Material

#### A. *General:*

The Radiation Safety Office must approve all transfer of radioactive materials, either between Authorized Users at Old Dominion University or to individuals or institutions outside of the University prior to the transfer.

#### B. *Transfers Between Authorized Users:*

An Authorized User must obtain prior written approval of the Radiation Safety Office prior to transferring radioactive material to another Authorized User. Approval is required regardless of the quantity of material being transferred. Written requests to transfer radioactive material must contain the following information:

1. The radionuclide being transferred.
2. The chemical form of the radiolabeled material.
3. The total activity of the material intended to be transferred.

Approvals for transfers between Authorized Users will be granted provided that:

1. The recipient of the transfer has been approved by the Radiation Safety Committee to possess the particular radionuclide.
2. The recipient of the transfer has been approved by the Radiation Safety Committee to use the radionuclide in its specific chemical form.
3. The activity transferred, when added to the recipient's current inventory does not exceed his/her approved limits.

#### C. *Transfers to Other Licensees:*

The transfer of radioactive material to individuals not employed by the University, and to other institutions is the responsibility of the Radiation Safety Office. Federal and state regulations require that the University verify that the recipient has a current license to possess the type(s) and quantity(s) of radioactive material transferred.

Authorized Users must notify the Radiation Safety Officer in writing prior to the transfer. The written notification must contain the following information:

1. The name of the individual or the recipient institution.
2. The name of the individual receiving the material at the recipient institution.

3. The radionuclide being transferred.
4. The chemical form and activity of the material.

Transfer approvals will be granted provided that the individual's or institution's license conditions and possession limits allow the acquisition and possession of the type(s) and amount(s) of the radionuclide(s) being transferred.

The recipient or a representative of the institution receiving the transferred material is required to sign RSO-25, *Transfer of Radioactive Material* (see Appendices B and C). The Radiation Safety Office in accordance with applicable provisions of 10 CFR 30.51 maintains records of transfers.

## Section XVII.

### Radioactive Waste Disposal

#### A. *General:*

Radioactive waste is categorized as to its physical form, its chemical form or the characteristics of the radionuclide contained in the waste. Seven categories are recognized: solid waste, liquid waste, liquid scintillation vials, contaminated animal carcasses, decay-in-storage waste, sealed sources and mixed waste. All users of radioactive material have a responsibility to minimize the volume of waste they generate, and to package, label and store the waste in a manner consistent with good radiological health practices.

The Radiation Safety Office provides for radioactive waste disposal, including furnishing containers and absorbent materials for the storage of waste, required forms, and consultation. The Radiation Safety Office also removes waste from laboratories, and arranges for its final disposition. Packaging of radioactive waste for pick-up and any recordkeeping associated with the waste are the responsibility of the Authorized User. As with all radioactive material, radioactive waste must be stored in a *Restricted Area* and secured to prevent unauthorized removal.

#### B. *General Requirements for Disposal of Solid Waste:*

Solid waste is defined as a dry active waste containing less than 0.5% (by volume) of freestanding liquid. Solid waste cannot contain active pathogenic or infectious agents, or any RCRA hazardous waste (e.g., heavy metals, oxidizers or acutely toxic chemicals). Except with prior approval, solid waste must be segregated according to its physical form and by radionuclide. Solid waste containing radionuclides with half-lives greater than 120 days should always be segregated from waste with half-lives less than 120 days (see this section, *General Requirements for the Disposal of Decay-in-Storage Waste*, page 43). It is the responsibility of the generator to estimate solid waste activity.

Solid waste containers must be clearly labeled with the following information:

1. The radionuclide(s) contained in the waste.
2. The activity of the waste (as estimated).
3. The date(s) of disposal.
4. The Authorized User's name.
5. The physical and/or chemical form of the waste.

Solid waste must be stored in a secure area. Authorized Users must submit RSO-50, *Service Request Form – Radioactive Waste Removal* (see Appendices B and C), to the Radiation Safety Office for solid waste pick-up and disposal.

Solid radioactive waste can be characterized as either "incinerable" or "non-incinerable" material according to its constituents:

1. "Incinerable" solid waste:

In general, incinerable solid waste is waste that can be incinerated with substantial volume reduction. Incinerable solid waste should be segregated from non-incinerable waste in clear plastic bags placed in cardboard boxes. Plastic bags and boxes are available from the Radiation Safety Office. The Radiation Safety Office is not responsible for sorting waste after accumulation.

a. Materials that are acceptable for incineration include:

Cotton cloth and rags	Polyester
Polystyrene	Polystyrene
Natural rubber	Latex
Polyurethane	Wood
Nitrile/nitrile rubber	Polyurethane
Leather	Polycarbonate
Urethane	Nylon
Polyethylene	Polypropylene

Certain other materials may be accepted for incineration; however, prior approval to incinerate them is required.

b. Materials unacceptable for incineration include:

Metal	Asbestos
Glass (> 5% total volume)	Explosives
Sharps	Pyrophorics
Polyvinyl chloride (PVC)	Etiological waste
* RCRA hazardous waste	

c. Radionuclide limits:

The average concentration of radionuclide constituents must not exceed the limits listed in Table XVIIa. (following page).

\* Call the Environmental Health and Safety Office (683-4495) for information regarding RCRA hazardous chemicals.

Table XVII.a: Incinerable Solid Waste Concentration Limits <sup>1</sup>

Radionuclide(s)	Average Concentration	
	Per cubic foot (ft <sup>3</sup> )	Per pound (lb.)
Total of all radionuclides with half-lives > 5 years	< 0.2 mCi (7.4 MBq)	< 0.02 mCi (740 kBq)
Total of all radionuclides with half-lives < 5 years	< 0.25 mCi (9.25 MBq)	< 2.5 mCi (92.5 MBq)
<sup>3</sup> H	< 0.2 mCi (7.4 MBq)	< 0.002 mCi (74 kBq)
<sup>14</sup> C	< 0.1 mCi (3.7 MBq)	< 0.001 mCi (37 kBq)

<sup>1</sup> Current as of February 1999/Generally accepted waste industry standard

2. "Non-incinerable" solid waste

In general, non-incinerable solid waste is waste that will not undergo substantial volume reduction if incinerated. Non-incinerable solid waste should be segregated from incinerable waste in clearly labeled containers provided by the Radiation Safety Office. The Radiation Safety Office is not responsible for sorting waste after accumulation.

a. Non-incinerable materials include:

- |                      |                           |
|----------------------|---------------------------|
| Metal                | Asbestos                  |
| Explosives           | Glass (> 5% total volume) |
| Sharps               | Pyrophorics               |
| RCRA hazardous waste | Polyvinyl chloride (PVC)  |
| Etiological waste    |                           |

C. *General Requirements for Disposal of Liquid Waste:*

Except for liquid generated from the rinsing of contaminated labware (tertiary rinses and beyond), Authorized and Qualified Users must not discharge liquid radioactive waste to the sanitary sewer system.

Liquid waste must be soluble or readily dispersible biological material. Liquid radioactive waste containing \*RCRA hazardous chemicals must not be discharged into the sanitary sewer (see this section, *General Requirements for Disposal of Mixed Waste*, page 44).

\* Call the Environmental Health and Safety Office (683-4495) for information regarding RCRA hazardous chemicals.

Liquid waste should be collected in wide-mouthed containers and should be stored in a secure location. Containers should be clearly labeled with the following information:

1. The radionuclide(s) and chemical constituents of the liquid.
2. The Authorized User's name.

Authorized Users should submit RSO-50, *Service Request Form – Radioactive Waste Removal* (Appendices B and C), to the Radiation Safety Office for liquid waste pick-up and disposal. The Radiation Safety Office in accordance with the provisions of 10 CFR 20.2003 disposes of all radioactive liquid waste.

D. *General Requirements for Disposal of Liquid Scintillation Vials:*

Liquid scintillation cocktail, regardless of its formulation must never be discharged into the sanitary sewer system. Liquid scintillation vials must be segregated according to activity and/or radionuclide and stored in a secure area designated as restricted. All storage containers must be properly labeled (see Section XII., page 27). Authorized Users must submit RSO-50, *Service Request Form – Radioactive Waste Removal* (see Appendices B and C), to the Radiation Safety Office for waste vial pick-up and disposal.

Liquid scintillation vials can be classified as either "deregulated" or "regulated" in accordance with the activity limits listed in Table XVII.b (below). Deregulated liquid scintillation vials can be disposed of without regard to radioactivity, i.e., as chemical waste. Regulated liquid scintillation vials must be disposed of as radioactive waste.

Table XVII.b: Concentration Limits for Deregulated and Regulated Liquid Scintillation Vials <sup>1</sup>

Vial Classification	Concentration
Deregulated	≤ 0.05 μCi of H-3 or C-14 per gram of scintillation media. <sup>2</sup>
Regulated	a. Any radionuclide besides H-3 or C-14 (regardless of conc.). <sup>3</sup> b. ≥ 0.05 μCi of H-3 or C-14. per gram of scintillation media <sup>2</sup>

<sup>1</sup> 10 CFR 20.2005(a)(1).

<sup>2</sup> 0.05 μCi per gram is approximately 111,000 dpm/ml. of scintillation cocktail assuming that the specific gravity of the cocktail is 1.0 (1gm/cm<sup>3</sup>).

<sup>3</sup> 10 CFR 20.2005(a)(1) applies to H-3 and C-14 only.

E. *General Requirements for Disposal of Animal Carcasses:*

Animal carcasses must be double bagged in opaque plastic bags. Absorbent material must be added to absorb body fluids. The bagged animal carcass must be labeled and placed in a properly labeled freezer. Bag labels should have the following information:

1. The radionuclide(s) contained in the carcass (bag or container).
2. The total activity of the waste (as estimated).
3. The approximate weight of the bag and carcass.
4. The date of disposal.
5. The Authorized User's name.

Animal carcasses containing radioactive material can be categorized as either "deregulated" or "regulated" according to the concentration limits listed in Table XVII.c (below). "Deregulated" animal carcasses can be disposed of without regard to radioactivity, i.e., as normal biological waste. "Regulated" animal carcasses must be disposed of as radioactive waste.

Table XVII.c: Concentration Limits for Deregulated and Regulated Animal Carcasses <sup>1</sup>

Vial Classification	Concentration
Deregulated	$\leq 0.05 \mu\text{Ci}$ of H-3 or C-14 per gram of animal tissue. <sup>2</sup>
Regulated	a. Any radionuclide besides H-3 or C-14 (regardless of conc.). <sup>3</sup> b. $\geq 0.05 \mu\text{Ci}$ of H-3 or C-14. per gram of animal tissue <sup>2</sup>

<sup>1</sup> 10 CFR 20.2005(a)(2).

<sup>2</sup> Averaged over the entire weight of the animal / For a 25 gram mouse 0.05  $\mu\text{Ci}$  per gram corresponds to 1.25  $\mu\text{Ci}$  total activity, for a 500 gram rat 0.05  $\mu\text{Ci}$  per gram corresponds to 25  $\mu\text{Ci}$  total activity and for a 4500 gram rabbit 0.05  $\mu\text{Ci}$  per gram corresponds to 225  $\mu\text{Ci}$  total activity.

<sup>3</sup> 10 CFR 20.2005(a)(2) applies to H-3 and C-14 only.

In addition to segregating animal carcasses according to concentration, animal carcasses containing radionuclides with half-lives greater than 120 days should always be segregated from carcasses with half-lives less than 120 days (see this section, *General Requirements for the Disposal of Decay-in-Storage Waste*, page 44).

Authorized Users must submit RSO-50, *Service Request Form – Radioactive Waste Removal* (see Appendices B and C), to the Radiation Safety Office for animal carcass pick-up and disposal.

F. *General Requirements for Disposal of Decay-in-Storage Waste:*

Old Dominion University is allowed to hold for decay-in-storage, waste containing radionuclides with half-lives *less than 120 days* for a minimum of 10 half-lives before disposal as "ordinary" (non-radioactive) waste. Surveys of decay-in-storage waste are performed by the Radiation Safety Office prior to disposal.

1. Waste containing radionuclides with half-lives < 120 days should be segregated (in separate containers) from waste with half-lives > 120 days.
2. Labels on waste items with the radiation symbol, and wording such as "Caution, Radioactive Material" should either be removed or defaced before deposited into decay-in-storage containers.
3. Decay-in-storage waste need not be segregated as "incinerable" and "non-incinerable"; however, as with other solid waste, decay-in-storage waste cannot contain \*RCRA hazardous chemicals.
4. Animal carcasses that are held for decay-in-storage must be kept frozen in a properly labeled, secure freezer.
5. Decay-in-storage waste containers must be labeled with the following information:
  - a. The radionuclide(s) contained in the waste.
  - b. The activity of the waste (as estimated) on the date(s) of disposal.
  - c. The date(s) of disposal.
  - d. The Authorized User's name.
  - e. The physical and/or chemical form of the waste.

Authorized Users must submit RSO-50, *Service Request Form – Radioactive Waste Removal* (see Appendices B and C), to the Radiation Safety Office for decay-in-storage waste pick-up and disposal.

G. *General Requirements for Disposal of Sealed Sources:*

Authorized Users must submit RSO-50, *Service Request Form – Radioactive Waste Removal* (see Appendices B and C), to the Radiation Safety Office for sealed source pick-up and disposal.

\* Call the Environmental Health and Safety Office (683-4495) for information regarding RCRA hazardous chemicals.

H. *General Requirements for Disposal of Mixed Waste:*

A waste, either solid or liquid, is considered a "mixed waste" if it contains a \*RCRA hazardous chemical and radioactive material. Both the US NRC (for the radioactive component) and US EPA (for the RCRA hazardous chemical component) regulate mixed waste.

The generation of mixed waste is not permitted without prior approval of the Radiation Safety Committee and the Radiation Safety Office. Expenses associated with disposal of mixed waste are the responsibility of the generator.

\* Call the Environmental Health and Safety Office (683-4495) for information regarding RCRA hazardous chemicals.

## Section XVIII.

### Contamination Surveys

#### A. General:

Contamination is defined as the presence of radioactive material on surfaces (e.g., floors, bench tops, chairs, etc.) and equipment where *it is undesired*. Contamination can either be *fixed* or *removable*. When contamination is present, there is the potential for internal deposition of the contaminant by inhalation, absorption and/or ingestion, as well as external exposure.

Contamination surveys, which are required as a condition of Old Dominion University's US NRC and Commonwealth of Virginia materials licenses, are an essential part of any radiation protection program. Areas where radioactive material is used and stored, and equipment used to manipulate radioactive material must be surveyed for both fixed and removable contamination on a routine basis according to the frequency intervals described in paragraph B, *Survey Frequency* (below).

#### B. Survey Frequency:

Contamination surveys (wipe tests) are required in all areas where unsealed sources of radioactive material are used and/or stored. The frequency of surveys depends on factors such as the types and quantities of radioactive material used and the types of operations being performed in the laboratory; however, regardless of those factors, surveys must be performed at intervals *not to exceed one calendar quarter*. The Radiation Safety Committee may also require additional surveys as deemed necessary and prudent.

Laboratories are classified into three (3) groups according to the radionuclides used in the laboratory, and the type(s) and nature of the operation(s) using the radionuclide(s). Laboratory classification and the frequency of required surveys are listed in Tables XVIII.a (below) and XVIII.b (page 46):

Table XVIII.a: Laboratory Classes <sup>1</sup>

Laboratory Type	Survey Frequency
Type A	Daily
Type B	Weekly
Type C	Monthly or quarterly

<sup>1</sup> Patterned after the *Recommendation of the International Commission on Radiological Protection-Report of Committee V, 1965*.

Table XVIII.b: Laboratory Classification Determination Based on Activity Present <sup>1</sup>

Radiotoxicity Group <sup>2</sup>	Laboratory Classification		
	Type C	Type B	Type A
Very High	<10 $\mu$ Ci (<370 kBq)	10 $\mu$ Ci to 10 mCi (370 kBq to 370 MBq)	>10 mCi (>370 MBq)
High	<100 $\mu$ Ci (<3.7 MBq)	100 $\mu$ Ci to 100 mCi (3.7 MBq to 3.7 GBq)	>100 mCi (>3.7 GBq)
Moderate	< 1 mCi (<37 MBq)	1 mCi to 1 Ci (37 MBq to 37 GBq)	>1 Ci (>37 GBq)
Low	<10 mCi (<370 MBq)	10 mCi to 10 Ci (370 MBq to 370 GBq)	>10 Ci (>370 GBq)

<sup>1</sup> Patterned after the *Recommendation of the International Commission on Radiological Protection-Report of Committee V*, (1965).

<sup>2</sup> See Table XVIII.d, "Toxicity Groups / Representative Radionuclides," page 47.

Table XVIII.c: Modifying Conditions for Laboratory Classification <sup>1</sup>

Procedure	Modifying Factor
Storage of stock solutions	$\times 100$
Very simple wet operations	$\times 10$
Normal chemical operations	$\times 1$
Complex wet operations	$\times 0.1$
Simple dry operations	$\times 0.1$
Dry and/or dusty operations	$\times 0.01$

<sup>1</sup> Patterned after the *Recommendation of the International Commission on Radiological Protection-Report of Committee V*, (1965).

Table XVIII.d: Toxicity Groups / Representative Radionuclides <sup>1</sup>

Toxicity Group	Representatives <sup>2</sup>
Very High Toxicity	Sr-90 + Y-90, Ra-226 and daughters, Pu-239, Am-241
High Toxicity	Na-22, Cl-36, Ca-45, Co-60, I-125, I-131, Cs-137, Eu-154
Moderate Toxicity	C-14, P-32, S-35, Cr-51, Fe-59, Ni-63
Slight Toxicity	H-3, Tc-99m, I-129, Th (naturally occurring), U (naturally occurring)

<sup>1</sup> Patterned after the *Recommendation of the International Commission on Radiological Protection-Report of Committee V*, (1965).

<sup>2</sup> Radionuclides listed are commonly used in research institutions like Old Dominion University. This list is not inclusive.

To determine the laboratory classification (and therefore the frequency of contamination surveys), multiply the activity range from Table XVIII.b (page 46) by the appropriate "modifying factor" from Table XVIII.c (page 46). The activity range determined for each radionuclide present determines the laboratory classification. For example, if a laboratory is using P-32 in "very simple wet operations," and the maximum activity in the lab is 1 mCi (37 MBq):

1. P-32 is classified as "moderately toxic."
2. The modifying factor for "very simple wet operations" is 10.
3. Multiply the maximum activity in the laboratory (1 mCi) by 10 (=10 mCi).
4. The laboratory would be classified as "Type C" because the laboratory uses <10 mCi (370 MBq) of material at a time.
5. Type C laboratories are required to survey *monthly* or *quarterly*.

C. *Survey Procedures:*

1. Surveys to determine fixed contamination levels:

As the name implies, fixed contamination is "fixed" in place and cannot be spread; therefore, depending on the radioactive contaminant, it may pose an external exposure hazard only.

Fixed radioactive contamination can be detected only with a portable survey instrument such as a "Geiger counter." The instrument must be appropriate to detect the type and quantity of contamination present. It is prudent practice to periodically test an area with confirmed fixed contamination to determine if the contamination has become removable. This is

especially true for high traffic areas and areas that are subject to mechanical abrasion and weathering.

Fixed contamination surveys using a portable detection instrument:

- a. Using a slow sweeping motion, i.e., 5 to 10 cm per second, survey area(s) of 100 cm<sup>2</sup> (4" × 4") for smaller surfaces, and areas up to 300 cm<sup>2</sup> (≈7" × 7") for larger surfaces (such as floors). The detector should be no more than 1 inch from the surface being surveyed. Areas that should be surveyed include floors, bench tops, refrigerators and freezers and sinks.
- b. If a contaminated area is suspected, steady the detector over the suspected area to confirm or disprove the presence of contamination.
- c. If an area of contamination is confirmed, perform a wipe test to determine if the contamination is fixed or removable (see below).
  - (1) The presence of fixed contamination should be noted along with the measured exposure rate, (obtained with the portable detector) if applicable.
  - (2) Removable contamination levels should be quantified using a liquid scintillation counting system or gamma scintillation counting system (whichever is appropriate).

2. Surveys to determine removable contamination levels:

Removable radioactive contamination is generally a more serious problem than fixed contamination as it can be readily spread to other surfaces (in most cases). One accepted method for the detection of removable contamination is the *wipe (also swipe or smear) test*:

- a. Prepare a map or list of the area(s) and/or article(s) to be surveyed. Each area or article to be surveyed should be assigned an identifying number or letter, to correspond with each wipe sample. Examples of area(s) and equipment that should be included in a removable contamination survey are:
  - (1) Benches, tables, floors, counter tops, hot sinks, and cabinets and drawers where potentially contaminated equipment is stored.
  - (2) Balances, stirrers, fraction collectors and centrifuges used for radiation work.
  - (3) Radioactive stock storage and waste storage areas.
  - (4) Refrigerators, freezers, cold rooms and fume hoods.

- b. Wipe surfaces of approximately  $100 \text{ cm}^2$  ( $4" \times 4"$ ) with a small filter paper or cotton-tipped applicator. The filter paper or applicator may be moistened with either water or alcohol. Surfaces should be wiped from areas of lower suspected contamination to areas of higher suspected contamination
- c. For larger surfaces such as floors, bench and counter tops, and floors, wipes can be taken over areas of up to  $300 \text{ cm}^2$  ( $\approx 7" \times 7"$ ) and contamination levels (if any) averaged over  $100 \text{ cm}^2$ .
- d. Wipe sample contamination levels should be quantified using a liquid scintillation counter or gamma scintillation counter (whichever is appropriate).

The presence of removable contamination can also be determined by using a portable survey instrument. Surveying with a portable instrument may augment, but not replace, wipe testing as the method for determining removable contamination levels:

- a. Using a slow sweeping motion, i.e., 5 to 10 cm per second, survey area(s) of  $100 \text{ cm}^2$  for smaller surfaces and up to  $300 \text{ cm}^2$  for larger surfaces. The detector should be no more than 1 inch from the surface being surveyed.
- b. If a contaminated area is suspected, steady the detector over the area to confirm or disprove the presence of contamination.
- c. If an area of contamination is confirmed, perform a wipe test to determine if the contamination is fixed or removable.
  - (1) The presence of fixed contamination should be noted along with the measured level (obtained with the portable detector).
  - (2) Removable contamination levels should be quantified using a liquid scintillation counting system or gamma scintillator.

D. *"Acceptable" Contamination Levels for Areas, Clothing and Equipment:*

Areas should be maintained essentially free of removable contamination. Old Dominion University recognizes an "action" level for decontamination of  $100 \text{ dpm}/100 \text{ cm}^2$  above background for high traffic and common areas of a Restricted Area.

Dedicated equipment, i.e., equipment used exclusively for radiation work, and areas and clothing that have contamination levels in excess of the limits listed in Table XVIII.e (page 50) must be decontaminated immediately. If decontamination procedures do not lower contamination to levels at or below the specified limits, the equipment, area or clothing must be clearly labeled so as to warn of the presence of contamination.

Table XVIII.e: "Acceptable" Contamination Limits <sup>1</sup>

Surface Type	Type of Radioactive Material / Contamination Limits <sup>2</sup>		
	Alpha Emitters	Beta/Gamma Emitters <sup>3</sup>	Low Risk Beta/X-Ray Emitters <sup>4</sup>
Unrestricted Areas	2.2 dpm/cm <sup>2</sup> (10 <sup>-7</sup> μCi/cm <sup>2</sup> )	22 dpm/cm <sup>2</sup> (10 <sup>-6</sup> μCi/cm <sup>2</sup> )	220 dpm/cm <sup>2</sup> (10 <sup>-5</sup> μCi/cm <sup>2</sup> )
Restricted Areas and Dedicated Equipment	22 dpm/cm <sup>2</sup> (10 <sup>-6</sup> μCi/cm <sup>2</sup> )	220 dpm/cm <sup>2</sup> (10 <sup>-5</sup> μCi/cm <sup>2</sup> )	2,200 dpm/cm <sup>2</sup> (10 <sup>-4</sup> μCi/cm <sup>2</sup> )
Personal Clothing (worn outside the restricted area)	2.2 dpm/cm <sup>2</sup> (10 <sup>-7</sup> μCi/cm <sup>2</sup> )	22 dpm/cm <sup>2</sup> (10 <sup>-6</sup> μCi/cm <sup>2</sup> )	220 dpm/cm <sup>2</sup> (10 <sup>-5</sup> μCi/cm <sup>2</sup> )
Protective Clothing (worn only in the restricted area)	22 dpm/cm <sup>2</sup> (10 <sup>-6</sup> μCi/cm <sup>2</sup> )	220 dpm/cm <sup>2</sup> (10 <sup>-5</sup> μCi/cm <sup>2</sup> )	2,200 dpm/cm <sup>2</sup> (10 <sup>-4</sup> μCi/cm <sup>2</sup> )
Skin	22 dpm/cm <sup>2</sup> (10 <sup>-6</sup> μCi/cm <sup>2</sup> )	22 dpm/cm <sup>2</sup> (10 <sup>-6</sup> μCi/cm <sup>2</sup> )	220 dpm/cm <sup>2</sup> (10 <sup>-5</sup> μCi/cm <sup>2</sup> )

<sup>1</sup> From US NRC Regulatory Guide 8.23, *Radiation Surveys at Medical Institutions* (1981).

<sup>2</sup> Averaging is acceptable over nonliving areas of up to 300 cm<sup>2</sup> or, for floors, walls, and ceiling, 100 cm<sup>2</sup>. Averaging is also acceptable over 100 cm<sup>2</sup> for skin or, for the hands, over the whole area of the hand, nominally 300 cm<sup>2</sup>.

<sup>3</sup> Limits are acceptable for all beta or x-ray emitters other than those considered low risk.

<sup>4</sup> Low-risk nuclides include C-14, H-3, S-35, Tc-99m, and other whose beta energies are less than 0.2 MeV maximum, whose gamma or x-ray emission is less than 0.1 R/h at 1 meter per curie, and whose DAC is greater than 10<sup>-6</sup> μCi/ml.

E. "Acceptable" Contamination Levels for Unconditional Release of Areas, Clothing, and Equipment:

If equipment, areas, and/or clothing are to be released unconditionally for unrestricted usage, contamination levels shall be at or below the limits listed in Table XVIII.f (page 51). If decontamination procedures on equipment, areas, and/or clothing do not reduce contamination below Table XVIII.f levels, the equipment and/or clothing can either be held for decay (if the half-life of the radionuclide is <120 days) or disposed of as radioactive waste.

Table XVIII.f: "Acceptable" Contamination Limits for Unconditional Release of Areas, Clothing, and Equipment <sup>1,2</sup>

Nuclide <sup>3</sup>	Removable Contamination <sup>4,6</sup>	Average Contamination <sup>4,5</sup>	Maximum Contamination <sup>4,6</sup>
Natural Uranium, U-235, U-238, and associated decay products	10 dpm/cm <sup>2</sup>	50 dpm/cm <sup>2</sup>	150 dpm/cm <sup>2</sup>
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	0.2 dpm/cm <sup>2</sup>	1.0 dpm/cm <sup>2</sup>	1.0 dpm/cm <sup>2</sup>
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	2.0 dpm/cm <sup>2</sup>	10 dpm/cm <sup>2</sup>	30 dpm/cm <sup>2</sup>
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above <sup>15</sup>	10 dpm/cm <sup>2</sup>	50 dpm/cm <sup>2</sup>	150 dpm/cm <sup>2</sup>

<sup>1</sup> From US NRC Regulatory Guide 8.23, *Radiation Surveys at Medical Institutions* (1981).

<sup>2</sup> The amount of removable radioactive material per 100 cm<sup>2</sup> of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. (Note: The use of dry material may not be appropriate for tritium). When removable contamination on objects of surface area less than 100 cm<sup>2</sup> is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped.

<sup>3</sup> Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides apply independently.

<sup>4</sup> As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

<sup>5</sup> Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each object.

<sup>6</sup> The maximum contamination level applies to an area of not more than 100 cm<sup>2</sup>.

F. *Survey Records:*

The results of surveys must be documented (see Appendix C). Survey records are the property of the licensee, not the individual user, and must be retained for a minimum of 3 years from the date the record was made (as required by 10 CFR 20.2103). Survey records must also be available for inspection upon the request of the Radiation Safety Office and/or representatives of regulatory agencies.

1. Survey record format

Each survey record, *including surveys with portable detection instruments*, must have, as a minimum, the following information (see Appendix C):

- a. Location of the survey, i.e., building and room number.
- b. Identifying map or list of the equipment, area(s) or clothing surveyed.
- c. Date the survey was performed.
- d. Surveyor's signature or initials.

2. Acceptable units for recording surveys

Contamination survey results must be recorded in units of either *dpm/100 cm<sup>2</sup>* or *μCi/100 cm<sup>2</sup>* where:

$$\text{dpm}/100\text{ cm}^2 = \frac{\text{gross cpm}/100\text{ cm}^2 - \text{background}}{\text{detector efficiency (for the radionuclide)}} = \frac{\text{net cpm}/100\text{ cm}^2}{\text{detector efficiency}}$$

and

$$\mu\text{Ci}/100\text{ cm}^2 = \frac{\text{dpm}/100\text{ cm}^2}{2.22 \times 10^6} \quad \text{or} \quad \mu\text{Ci}/100\text{ cm}^2 = (\text{dpm}/100\text{ cm}^2)(4.505 \times 10^{-7})$$

## Section XIX.

### External Radiation Exposure Surveys

#### A. *General:*

Surveys must be conducted to assess the potential for external radiation exposure from gamma and x-ray emitting radionuclides (I-125, Co-57, Cs-137, etc.) as well as high-energy beta emitters (such as Sr-90/Y-90, P-32, etc.). Excluded from such surveys are low energy beta emitters such as tritium (H-3), C-14, P-33, S-35, and Ca-45 as well as pure alpha emitters, since they pose no external exposure hazard.

If an individual in a particular area is likely to receive an annual dose equivalent (from external sources of radiation) greater than 10% of the allowable annual occupational limits (see Section VII., Table VII.a, page 15 and Table VII.b, page 16), external radiation surveys are required for that area.

#### B. *Survey Frequency:*

Exposure rate surveys shall be performed:

1. Upon acquisition of a source or sources;
2. Upon acquisition of an additional source or sources;
3. Upon moving the source or sources to a different location; and,
4. Upon a change in the type of shielding, shielding configuration, or shielding thickness.

#### C. *Exposure Rate Limits:*

Under no circumstances shall an individual member of the public be exposed to radiation levels exceeding 2 mrem (0.02 mSv) an hour from external sources of exposure or to a combined 100 mrem (1 mSv) annually from the combination of external exposure and internal exposure resulting from the use of licensed material at the University.

#### D. *Selection of Appropriate Portable Survey Instruments:*

The instrument selected for survey must have a current calibration and be calibrated with a *source* of the same or similar energy. *Instruments calibrated electronically are unacceptable for exposure rate surveys.*

E. *Survey Records:*

The results of each survey must be documented. Records of surveys must be retained until termination of Old Dominion University's US NRC and Commonwealth of Virginia licenses. Survey records must be available for inspection upon the request of the Radiation Safety Office and/or representatives of regulatory agencies.

1. Survey record format

Each survey record shall have, as a minimum, the following information:

- a. Location of the survey, i.e., building and room number;
- b. Identifying map or list of the area(s) surveyed;
- c. Date the survey was performed;
- d. Purpose of the survey, i.e., acquisition of a new source(s) or additional source(s) or change in the shielding configuration;
- e. Make, model, and serial number of each portable survey instrument;
- f. Calibration date for each portable survey instrument;
- g. Average correction factor(s) used in calculation of exposure or dose equivalent rate determination; and,
- h. Surveyor's signature or initials.

2. Acceptable units for recording surveys

Exposure and dose equivalent rate surveys shall be recorded in units (or subunits) of *rem/hr* or *Sievert/hr (Sv/hr)* where:

$$1 \text{ rem} = 0.01 \text{ Sv} \quad \text{and} \quad 1 \text{ Sv} = 100 \text{ rem}$$

## Section XX.

### External Personal Monitors

#### A. General:

All radiation workers who are likely to receive a radiation dose greater than 10 percent of the occupational dose limits (see Section VII., Tables VII.a, page 15 and VII.b, page 16) shall be issued appropriate personal monitoring devices:

Table XX.a: Annual Dose Requiring External Personal Monitoring Devices

Exposure Category	Annual Dose Requiring External Monitoring <sup>1</sup>
Whole Body <sup>2</sup>	0.500 rem (0.005 Sv)
Lens of the Eye <sup>3</sup>	1.5 rem (0.015 Sv)
Extremities and Skin <sup>4</sup>	5 rem (0.05 Sv)
Minors <sup>5</sup>	0.05 rem (0.5 mSv)
Embryo/Fetus (declared pregnant worker) <sup>6</sup>	0.05 rem (0.5 mSv)

<sup>1</sup> From 10 CFR 20.1502.

<sup>2</sup> Deep dose equivalent (DDE)/Dose equivalent to the whole body, i.e., the head (excluding the lens of the eye), trunk (excluding the male gonads), arms above the elbow, and legs above the knee, taken as the dose at a depth of 1 cm (1000 mg/cm<sup>2</sup>).

<sup>3</sup> Lens dose equivalent (LDE)/Dose equivalent to the lens of the eye at a depth of 0.3 cm (300 mg/cm<sup>2</sup>)

<sup>4</sup> Shallow dose equivalent (SDE)/Dose equivalent to the hands, elbows, arm below the elbow, knee or leg below the knee and skin of the body at a depth of 0.007 cm (7 mg/cm<sup>2</sup>).

<sup>5</sup> From 10 CFR 20.1207, an individual under 18 years of age.

<sup>6</sup> From 10 CFR 20.1208/Worker must declare her pregnancy for this limit to apply (see Section VIII.)//Total dose during the entire 9 month gestation period. Taken as the sum of the external dose and internal dose from radionuclides deposited in the mother.

The Radiation Safety Office shall procure, distribute, collect and provide for the processing of all personal monitoring devices. The Radiation Safety Officer will make the final determination on issuing personal dosimeters; however, it is the responsibility of the Authorized User to notify the Radiation Safety Office whenever additional external monitors may be required, e.g., new employees, declared pregnant worker(s), etc., and when activities requiring external monitors are terminated. Workers who require personal monitors must complete RSO-11, *Personnel Radiation Dosimetry Request* (Appendices B and C).

B. *Rules for the Use of Personal Monitors:*

1. Under no circumstances shall a personal monitor issued to one worker be worn by another worker.
2. At no time shall a worker deliberately expose a personal monitoring device to radiation unless the device is being worn during the performance of his/her job, or unless the Radiation Safety Officer has approved the exposure.
3. Personal monitors must not be worn during non-occupational radiation exposures such as a medical x-ray, a nuclear medicine procedure or radiation therapy.
4. Personal monitoring devices must be left at the workplace, and when not in use, shall be stored in an area with normal levels of background radiation.

C. *Types and Use of Specific Personal Monitors:*

Old Dominion University typically issues photographic dosimeters (film badges), and thermoluminescent dosimeters (TLD's) for occupationally exposed workers; however, devices such as pocket dosimeters may also be employed at the direction of the Radiation Safety Officer.

1. Film badges
  - a. Film badges used to measure whole body exposure must be worn as near the middle of the trunk as is practical.
  - b. Film badges used to measure embryo/fetus exposure must be worn as near the middle of the abdomen as is practical.
  - c. The open window of the badge, typically the side on which the name of the wearer is inscribed, must be oriented away from the body.
  - d. Film badges must be exchanged at a frequency recommended by the supplier (typically monthly or quarterly), or as directed by the Radiation Safety Officer.
  - e. If a worker suspects that he/she has received an exposure in excess of the limits specified in Section VII. (page 15), the worker must contact the Radiation Safety Officer immediately so that the film badge may be processed.
2. Thermoluminescent dosimeters (TLD's)
  - a. TLD's which are used to measure whole body exposure must be worn as near the middle of the trunk as is practical.

- b. TLD's which are used to measure embryo/fetus exposure must be worn as near the middle of the abdomen as is practical.
- c. For TLD's which are used to measure whole body or embryo/fetus exposure, the open window of the badge, typically the side on which the name of the wearer is inscribed, must be oriented away from the body.
- d. For ring-style TLD's which are used to measure extremity exposure, the ring badge must be worn under the worker's protective glove:
  - (1) The ring should be worn on the hand most frequently used to handle the source of radiation. For right-handed individuals the ring should be worn on the right hand and for left-handed individuals, the ring should be worn on the left hand.
  - (2) The ring should be worn on either the index or middle finger.
  - (3) The open window of the badge, typically the side on which the name of the wearer is inscribed, shall be oriented toward the palm side of the hand in the direction of the radiation source.
- e. TLD's shall be exchanged at a frequency recommended by the supplier (typically monthly or quarterly), or as directed by the Radiation Safety Officer.
- f. If an exposure in excess of the limits specified in Section VII. (page 15) is suspected, the Radiation Safety Officer must be notified immediately so that the TLD may be processed.

### 3. Pocket dosimeters

Pocket dosimeters are capable of providing an instantaneous measurement of total dose, and may be indicated by the Radiation Safety Officer to augment the use of film and/or TLD's where high exposure rates are expected.

#### D. *Exposure Records:*

The Radiation Safety Office in accordance with the applicable provisions of 10 CFR 19 and 10 CFR 20 (see Appendices D and E) maintains all personal monitoring records. Personal monitoring records must be retained until termination of Old Dominion University's US NRC and Commonwealth of Virginia licenses:

- 1. Old Dominion University's Radiation Safety Office shall provide each worker who has been issued a dosimeter, an annual report of his/her dose over the previous year.
- 2. Current exposure records, and the results of monthly and/or quarterly monitoring will be sent to each department for inspection.

3. At the written request of the worker, the Radiation Safety Office shall provide a report of the worker's annual dose for the period(s) the worker was issued dosimetry. This report shall be provided within 30 days of the request.
  - a. The request must be written and include the following information:
    - (1) The individual's name (as it appears in the records)
    - (2) The individual's social security number.
    - (3) Dates of employment.
    - (4) The individual's signature.
  - b. *Dosimetry records will not be released without permission of the individual for whom the records were made. The signature of the individual requesting the record(s) must accompany any request.*
4. Upon written request of a worker who is terminating his/her employment, the Radiation Safety Office shall provide a record of that worker's exposure during the current year at the time of termination. If the most current exposure results are unavailable, the Radiation Safety Officer must provide a written estimate of the worker's dose for the period in question.

E. *Lost and Damaged Dosimeters:*

Lost or damaged dosimetry must be reported to the Radiation Safety Office immediately. If an individual loses his/her dosimeter, or if a dosimeter is damaged to the extent that it cannot be processed, an estimate will be made for the period for which the dosimeter was assigned. Any radiation exposure estimate will become part of the individual's permanent exposure history at Old Dominion University.

Individuals who lose or damage their dosimeters must complete and return RSO-13, *Estimated Exposure for Lost or Damaged Dosimeters*, to the Radiation Safety Office before the exposure estimate can be made. Exposure estimates are made using on the following information:

1. The type(s) and activity(s) of the radiation to which the worker was occupationally exposed during the period the lost/damaged dosimeter was assigned.
2. The operations performed using the radiation sources during the assigned period, specifically if the operations are "routine" or are dissimilar from operations performed in the past.
3. The duration of the radiation exposure(s) during the assigned period.
4. Radiation exposures received by co-workers who perform the same or similar operations.

## Section XXI.

### Internal Personal Monitoring

A. *General:*

All workers over 18 years of age who are likely to receive an annual intake greater than 10% of the applicable annual limit on uptake, or ALI (found in 10 CFR 20, see Appendix E) must be monitored and their committed effective dose equivalent (CEDE) assessed.

Minors (under 18 years of age) and declared pregnant workers who are likely to receive an annual committed dose equivalent greater than 0.05 rem (0.5 mSv) must be monitored and their CEDE assessed.

B. *Tritium Bioassay:*

Tritium bioassays shall be performed for individuals who work with, or enter areas in which quantities of tritium exceed those levels listed in Table XXI.a:

Table XXI.a: Quantities of Tritium (H-3) Requiring Bioassay

Type of Operation	Form / Activity Requiring Bioassay <sup>1</sup>		
	Tritiated water, other tritiated compounds including nucleotide precursors	Tritium gas in sealed process vessels	Tritiated water mixed with >10 kg of inert H <sub>2</sub> O
Processes in open room or bench with possible escape from process vessels	100 mCi (3.7 GBq)	100 Ci (3.7 TBq)	10 mCi/kg (370 MBq/kg)
Processes with possible escape, carried out in a fume hood	1 Ci (37 GBq)	1000 Ci (37 TBq)	100 mCi/kg (3.7 GBq)
Processes carried out in gloveboxes that are normally closed but with possible release from process vessel and occasional exposure to contaminated box and leakage	10 Ci (370 GBq)	10,000 Ci (370 TBq)	1 Ci/kg (37 GBq/kg)

<sup>1</sup> From US NRC Regulatory Guide 8.32, *Criteria for Establishing a Tritium Bioassay Program*, (July 1988).

Tritium bioassays will consist of urinalysis by liquid scintillation counting, and will be performed by the Radiation Safety Officer at intervals described in US NRC Regulatory Guide 8.32, *Criteria for Establishing a Tritium Bioassay Program*, (July 1988). Bioassay records will be maintained in accordance with 10 CFR 20.2106 (see Appendix E). Bioassays are not required for operations using tritium sealed sources and metallic foils regardless of quantity.

C. *Radioiodine Bioassay:*

Radioiodine bioassays shall be performed for individuals who work with, or enter areas in which quantities of radioiodine exceed those levels in Table XXI.b, either on a single use basis or as the total activity introduced into processes during a period of 3 months:

Table XXI.b: Quantities of Radioiodine Requiring Bioassay

Type of Operation	Form / Activity Used in Unsealed Form <sup>1,2</sup>	
	Volatile or Dispersible	Bound to a Non-Volatile Agent
Processes in open room or bench with possible escape from process vessels	1 mCi (37 MBq)	10 mCi (370 MBq)
Processes with possible escape, carried out in a fume hood	10 mCi (370 MBq)	100 mCi (3.7 GBq)
Processes carried out in gloveboxes that are normally closed but with possible release from process vessel and occasional exposure to contaminated box and leakage	100 mCi (3.7 GBq)	1 Ci (37 GBq)

<sup>1</sup> From US NRC Regulatory Guide 8.20, *Applications of Bioassay for I-125 and I-131*, revision 1, (September 1979).

<sup>2</sup> Either single use or total activity used during a period of 3 months.

If the unsealed quantities of radioiodine handled are less than 10% of the quantities listed in Table XXI.b, routine bioassay might still be indicated. A written justification for not performing bioassays at those levels of use shall be prepared by the Radiation Safety Officer and presented to the Radiation Safety Committee for consideration.

Bioassays will consist of in vivo thyroid counts using a NaI(Tl) scintillation detector. The Radiation Safety Officer will perform the bioassay at intervals described in US NRC Regulatory Guide 8.20, *Applications of Bioassay for I-125 and I-131*, revision 1, (September 1979). Bioassay records will be maintained in accordance with 10 CFR 20.2106 (see Appendix E).

## Section XXII.

### Portable Survey Instruments: Inspection and Calibration

#### A. *Survey Instrument Inspection:*

Prior to operating a portable survey instrument, the individual using the instrument must perform a pre-operational inspection to verify that the instrument is in good working order. If any of the pre-operational inspection parameters are deficient, the instrument must be removed from service, repaired, and calibrated (if necessary). A pre-operational inspection includes:

1. Performing a visual inspection of the meter and detector. The individual performing the inspection should look for damage to instrument components such as cable(s), connector(s) the meter's dial, and the detector window, etc.
2. Confirming that the instrument has been calibrated within the required interval by checking the calibration sticker or tag (see Appendix B).
3. Checking the batteries and replacing weak and corroded batteries to ensure proper instrument operation.
4. Using a check source, determine if the detector is functioning properly. The apparent count rate/exposure rate for the check source is noted on the calibration sticker or tag. If the count rate/exposure rate measured during the preoperational inspection differs from the apparent rate by more than  $\pm 20\%$  the instrument must be taken out of service and repaired.

#### B. *Survey Instrument Calibration:*

Portable survey instruments shall be calibrated by the Radiation Safety Office except those requiring special procedure(s) and and/or equipment to calibrate. Instruments that cannot be calibrated by the Radiation Safety Office will be sent to a qualified vendor for calibration. The Radiation Safety Office will be responsible for costs relating to the calibration only. The owner of the instrument is responsible for any repair costs.

The calibration of portable survey instruments by Old Dominion University shall be conducted in accordance with the procedures outlined in US NRC Regulatory Guide 10.8, *Guide for the Preparation of Applications for Medical Use Programs*, (Revision 2, August 1987), Appendix B, "Model Procedure for Calibrating Survey Instruments." Qualified individuals as designated by the University's Radiation Safety Committee must perform instrument calibrations.

1. Frequency of calibration.

All portable survey instruments must be routinely calibrated *no less than annually*. Calibration is also required if the instrument has been serviced (except for battery replacement), or its configuration altered, e.g., cable replacement, high voltage adjustment, etc.

2. Acceptable methods for calibration:

- a. Survey instruments used exclusively for exposure rate measurement ("surveys of record") shall be calibrated with a radiation source, i.e., a beam calibrator, that emits radiation of approximately the same energy as the source(s) to be measured. The source activity or exposure rate (at a given distance) must be traceable to documented measurements to a standard certified within 5% by NIST.
- b. Survey instruments used exclusively for detecting the presence of radiation or those used for count rate determination only may be calibrated electronically using a pulser; however, such instruments must not be used for "surveys of record" as specified in 10 CFR 20.1301 and 20.1501 (see Appendix E). The electronic pulser itself must be calibrated no less than annually by the manufacturer or other company authorized to perform such calibrations.

3. Calibration sticker or tag:

A calibration sticker or tag shall be attached to survey instruments that have been satisfactorily calibrated (see Appendix C). Instruments that do not have a calibration sticker or tag attached must be taken out of service until they have been satisfactorily calibrated.

The calibration sticker or tag must be completed for each instrument and include the following information:

- a. The date the calibration was performed.
- b. The initials of the person who performed the calibration.
- c. The source or pulser used to calibrate the instrument.
- d. The average correction factor for each scale or decade or an indication that the scale or decade was not calibrated or was inoperable.
- e. The angle between the radiation flux and the detector during the calibration (in the case of instruments calibrated with a source).
- f. The apparent exposure rate or count rate of the check source.
- g. The date in which the instrument requires re-calibration.

An additional sticker or tag with the following (or similar) statement is also required for instruments that have been calibrated electronically: “This instrument may be used for contamination detection and for detecting the presence of radiation only. Do not use for exposure surveys” (see Appendix C).

4. Instruments out of service

If satisfactory tolerance cannot be achieved by manual adjustment, the instrument must be immediately removed from service and repaired. If the instrument is not immediately sent for repair, the instrument shall be rendered inoperable, and a tag or sticker with the statement (or equivalent statement) “Out of Service Do Not Use” must be attached.

C. *Calibration Records:*

A record of each instrument calibration must be made on RSO-31, *Survey Instrument Calibration Record: Source Calibrated Instruments* and RSO-32, *Survey Instrument Calibration Record: Pulsed Calibrated Instruments* (see Appendices B and C). The Radiation Safety Office maintains records of survey instrument calibrations.

## Section XXIII.

### Required Recordkeeping for Authorized Users

#### A. *General:*

Authorized Users are required to maintain three kinds of records: records of the receipt and disposal of radioactive material, records of current inventory and records of laboratory surveys.

#### B. *Receipt and Disposal Records:*

Authorized Users are required to maintain records of the receipt and disposal of all radioactive material obtained under their authorization. Receipt and disposal records must be maintained by the Authorized User until either termination of his/her authorization, or termination of his/her employment with Old Dominion University.

At which time the Authorized User terminates his/her authorization to possess radioactive material, or terminates employment with the University, all records of receipt and disposal of radioactive material must be relinquished to the Radiation Safety Office.

#### C. *Radioactive Materials Inventories:*

Authorized Users must maintain a *current* inventory of radioactive materials in his/her possession. This inventory must be maintained regardless of whether the material is being used. Records of past inventories must be maintained for a minimum of 3 years after the record was made.

At which time the Authorized User terminates his/her authorization to possess radioactive material, or terminates employment with the University, all records of past inventories must be relinquished to the Radiation Safety Office.

#### D. *Records of Laboratory Surveys:*

Authorized Users must maintain records of contamination surveys performed in his/her laboratory. Records of contamination surveys must be maintained for a minimum of 3 years after the record was made.

At which time the Authorized User terminates his/her authorization to possess radioactive material, or terminates employment with the University, all records of past inventories must be relinquished to the Radiation Safety Office.

## Section XXIV.

### Radiation Protection Program Review and Radiation Safety Audits

A. *Radiation Protection Program Review:*

The Radiation Safety Officer, the Radiation Safety Committee, and/or an independent consultant shall perform a review of the Radiation Protection Program content and implementation at least annually as specified in 10 CFR 20.1101. Results of the review along with recommendations (if any) for corrective action must be forwarded to Old Dominion University's Administration for consideration. Audit and review records must be maintained until termination of Old Dominion University's US NRC and Commonwealth of Virginia licenses.

B. *Laboratory Radiation Safety Audits:*

In addition to radiological surveys for contamination and external radiation exposure, the Radiation Safety Office conducts a thorough radiation safety audit at least quarterly in laboratories and areas where radioactive material is used and/or stored. The purpose of the audits is to:

1. Evaluate the adequacy of equipment in the laboratory, including portable survey and counting instruments.
2. Evaluate radiological control measures taken by laboratory workers, including the adequacy of radiological surveys, personal protective equipment and shielding.
3. Assess the need for additional worker training.
4. Evaluate the security of radioactive material.
5. Evaluate the adequacy of the laboratory's inventory control practices.
6. Ensure that the laboratory area is posted with:
  - a. Warning labels and signs consistent with the level of hazard, as specified in 10 CFR 20 (see Appendix E).
  - b. Notices, as specified in 10 CFR 19 (see Appendix D).
  - c. Emergency procedures and phone numbers.
7. Ensure that records of surveys and previous audits are current, properly maintained, and follow the accepted format, including the use of proper units.

The Radiation Safety Office shall maintain records of survey audits. Upon completion of each audit the Radiation Safety Office will inform each Authorized User, by report, of any deficiencies noted during the audit, and recommended actions to correct the deficiency. Audit records are the property of the licensee, not the individual user, and must be retained for a minimum of 3 years from the date

the record was made as required by 10 CFR 20.2102. Audit records must also be available for inspection upon the request of the Radiation Safety Office and/or representatives of regulatory agencies.

## Section XXV.

### Laboratory Closeout

#### A. *General:*

Authorized Users who wish to revoke their authorization to possess and use radioactive material for any reason, or are moving their laboratory to another room or building on campus, are responsible for the disposition of all radioactive material in their possession, and for surveys and decontamination (if necessary) of their laboratory.

#### B. *Disposition of Radioactive Material:*

Authorized Users must notify the Radiation Safety Office to arrange for the disposition of all radioactive material in their possession prior to revocation of their authorization to possess and use radioactive material, and prior to relocation of their laboratory on campus.

##### 1. Transfer of radioactive material:

Authorized Users must notify the Radiation Safety Office prior to transfer of radioactive material either to another Authorized User at Old Dominion University, or to another individual or institution not affiliated with the University. Transfers procedures are outlined in Section XVI. (page 36) of this manual.

##### 2. Radioactive material for disposal:

Authorized Users must package and label all radioactive material that will be disposed of as waste. Radioactive waste disposal, packaging and labeling procedures are outlined in Section XII. (page 27), and Section XVII. (page 38).

##### 3. Laboratory relocation:

Authorized Users must obtain approval from the Radiation Safety Committee prior to using or storing the material in a location different than the location specified on their current authorization to possess and use radioactive material (RSO-2 or RSO-6).

Authorized Users must submit RSO-6, *Application for Possession and Use of Radioactive Material: Renewal/Amendment* (see Appendices B and C) to the Committee amending their authorization (see Section IV., page 6) to include the new location where radioactive material will be used and/or stored. Radioactive material cannot be used and/or stored in the new location until the Committee has approved the amendment.

The Radiation Safety Office is responsible for transporting radioactive material between buildings on campus. Authorized Users must make prior arrangements with the Radiation Safety Office to transport radioactive material. If it is necessary, due to ongoing construction, renovation or pending Committee approval, Authorized Users must arrange for

the temporary storage of their radioactive material inventory with the Radiation Safety Office.

C. *Laboratory Closeout Surveys:*

Authorized Users must arrange with the Radiation Safety Office for a closeout survey of their laboratory or area prior to release of that laboratory or area for non-restricted use. The laboratory or area will be released for unrestricted use only if contamination levels are below the limits listed in Section XVIII., Table XVIII.f, (page 51). Laboratory fixtures such as fume hoods, fume hood ducting, fume hood blower assemblies, and drain traps will also be surveyed and removed if they are found to be contaminated, and decontamination measures fail to lower the contamination levels below those listed in Table XVIII.f. The Radiation Safety Office will retain records of closeout surveys.

All warning labels and signs bearing the radiation symbol and containing verbiage warning of the presence of radioactive material must be obliterated or removed before release of the laboratory or area for unrestricted use.

## **Section XXVI.**

### **Incident Reports to the Media**

It is the policy of Old Dominion University that the Office of Institutional Advancement coordinates all contact with the media. Prior to commenting to questions from members of the media, University employees must refer reporters to the Office of Institutional Advancement (683-3114). An employee's supervisor must also be informed of the media contact.

## **Section XXVII.**

### **Radiation Safety Committee**

#### **A. *General:***

The Radiation Safety Committee is a standing committee of Old Dominion University.

The Radiation Safety Committee is designated by the U.S. Nuclear Regulatory Commission (US NRC) as the responsible agent of the University in matters concerning conduct of the Radiation Protection Program. The Committee serves as the final authority in matters pertaining to the University's Radiation Protection Program including establishment of University policies and procedures, and decisions concerning compliance issues.

The Committee meets as often as necessary, but no less once each calendar quarter.

#### **B. *Radiation Safety Committee Responsibilities:***

1. Review all applications for possession and use of sources of ionizing radiation.
2. Establish policies and procedures to insure adequate protection for all persons occupationally exposed to ionizing radiation, as well as individual members of the public.
3. Review the content and conduct of the Radiation Protection Program at least annually.
4. In concert with the Radiation Safety Officer, review instances of alleged non-compliance with the Radiation Safety Officer and take appropriate corrective action(s).
5. Ensure that the US NRC and Commonwealth of Virginia material licenses are amended prior to any change in facilities, equipment, personnel, policies and/or equipment.

#### **C. *The Radiation Safety Committee Chair:***

The Radiation Safety Committee Chair is appointed by authority of the President and must be approved by the US NRC. The Chair has the responsibility to vote in all Committee matters, and along with the Radiation Safety Officer, must review and approve all User applications, and experimental protocols involving the use of radioactive material and radiation producing machines.

The Chair will also call for meetings of the Committee as necessary, but no less frequently than every calendar quarter. The Chair is responsible for reporting actions of the Committee to an administrative officer (of at least Vice Presidential status) of the University at least annually.

D. *Radiation Safety Committee Membership:*

The Radiation Safety Committee consists of at least five members. Members of the Committee are appointed by authority of the President of Old Dominion University and serve three (3) year terms. Appointees must satisfy the eligibility criteria specified in 10 CFR 33.13(c)(1), namely that the committee member is "a representative of management" or a person "trained and experienced in the safe use of radioactive materials."

A quorum consists of the Committee Chair, the Radiation Safety Officer, and at least two (2) other members. The Radiation Safety Officer, and the Director of Environmental Health and Safety, are permanent members of the Committee; however, neither will be eligible to serve as Chair.

## Section XXVIII.

### The Radiation Safety Officer

#### A. *General:*

The Radiation Safety Officer (RSO) is that person, who by reason of his/her education, training, and/or experience, is qualified to advise persons using radioactive material and radiation producing machines under the University's licenses in the safe use of ionizing radiation.

The primary mission of the RSO is to execute the policies and procedures established by the Radiation Safety Committee. The RSO falls under the supervisory and administrative control of the Director of Environmental Health and Safety, but reports directly to the Radiation Safety Committee in matters concerning the Radiation Protection Program. The RSO also serves as Secretary of the Radiation Safety Committee, and keeps Committee minutes and records.

The RSO has the authority to terminate a project, activity, or use of radioactive material or a radiation producing machine that is found to be a threat to health or property of individuals using the material or machine, or an individual member of the public. Termination action might include the closing of a laboratory, or the confiscation of radioactive material or a radiation producing machine, if such actions would prevent the recurrence of the threat to health or property. Any termination action shall be reported in writing to the Radiation Safety Committee Chair within 48 hours after such action has been taken.

#### B. *Radiation Safety Officer Responsibilities:*

1. Provide consultation to personnel at every level of responsibility at the University concerning all aspects of the Radiation Protection Program.
2. Ensure University compliance with US NRC and Commonwealth of Virginia license regulations and license conditions.
3. Prepare and submit license renewals and amendments to US NRC and the Commonwealth of Virginia.
4. Ensure that investigators comply with the conditions of their experimental protocols as specified and approved by the Radiation Safety Committee.
5. Review grant applications and provide guidance concerning compliance issues prior to the grant's submission.
6. Conduct training for occupationally exposed workers and ancillary personnel to comply with applicable federal and state regulations.
7. Receipt, survey and delivery, of all shipments of radioactive material received at the University.

8. Monitor and survey restricted areas:
  - a. Conduct routine contamination surveys as required.
  - b. Monitor exposure rates, as necessary, in areas in which photon-emitting radionuclides are used and/or stored and radiation producing machines are operated.
  - c. Conduct surveys for release of areas and equipment as non-restricted.
  - d. Conduct contamination surveys on equipment and areas prior to maintenance, repair or disposal (as ordinary waste).
9. Perform (routine) semi-annual leak tests on sealed sources and detector cells.
10. Perform leak tests on sealed sources and detector cells prior to transfer and upon receipt (as necessary). Notify the US NRC of reportable contamination levels on sealed sources and detector cells.
11. Manage the University's radiation dosimetry program:
  - a. Determine if dosimetry is required for occupationally exposed workers.
  - b. Distribute, collect and send dosimeters for processing.
  - c. Review exposure records, and distribute those records to workers who are issued dosimeters.
  - d. Maintain exposure records and provide those records to former program participants annually, upon employment termination and as requested by participants and their current or perspective employers.
  - e. Estimate exposures for employees who lose or damage dosimeters.
  - f. Estimate exposures for employees terminating employment with the University (for which exposure records are not available at the time of termination).
12. Manage the University's radioactive waste including waste storage and packaging of waste for off-site disposal. Maintain waste disposal records, and monitor air and liquid effluents.
13. Investigate incidents, unplanned releases of radioactive material to the environment, and other abnormal occurrences involving radiation or radioactive material.
14. Determine the need for bioassays on radiation workers:

- a. Evaluate bioassays, including determining internal dose(s) from bioassay results.
  - b. Maintain records of bioassay(s) and provide analyses and calculations of exposure to internally deposited radioactive material. Provide reports to workers as required.
15. Transfer of radioactive material to other licensees, including the packaging, surveys and shipment of the radioactive material.
16. Maintain a current inventory of all radioactive material at the University.
17. Supervise and/or assist in decontamination efforts in case of accidental spills or releases of radioactive material.
18. Calibrate portable radiation detection instruments.
19. Maintain other records not specifically designated above, for example, survey, transfer, receipt, and calibration records.

**Appendix A**

**Glossary of Radiation  
Protection Terms**

## Glossary

**Absorbed Dose (D):** The energy absorbed per unit mass at a specific place in an irradiated material. Measured in units of rad (1 rad = 0.01 J/kg.) and Gray (1 Gy = 1.0 J/kg.) where 1 Gy = 100 rad.

**Accelerator Produced Radioactive Material:** Radioactive material produced by bombarding a target material with high-energy charged particles.

**Airborne Radioactivity Area:** A room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations in excess of the derived air concentrations (DAC's) specified in appendix B to 10 CFR 20, or to such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

**ALARA:** Acronym for "as low as is reasonably achievable." In radiation protection it means making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the licensed activity is undertaken. In making this assessment the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to using nuclear energy and licensed materials in the public interest may all be taken into account.

**Alpha Decay:** Mode of radioactive decay in which an alpha particle is ejected from the nucleus of the parent atom. Following alpha decay, the daughter has an atomic number (Z) 2 amu less than the parent and an atomic mass (A) 4 amu less than the parent.

**Alpha Particle ( $\alpha$ ):** A charged particle (+2) emitted from the nucleus of an atom that has undergone alpha decay. Alpha particles have the same mass as a helium nucleus, i.e., 4.002603 amu. Alpha particles have limited ability to penetrate matter.

**Ancillary Personnel:** Persons such as housekeepers, maintenance workers, and police officers who do not work with radioactive material but may occasionally enter restricted areas as a function of their jobs.

**Annual Limit on Uptake (ALI):** The limit for radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. Inhalation or ingestion of one ALI will result in a committed effective dose equivalent of 5 rem (0.05 Sv) to the whole body, or a committed dose equivalent of 50 rem (0.5 Sv) to any individual organ or tissue. ALI values are given in table 1 columns 1 and 2 of appendix B to 10 CFR 20.

**Authorized User:** In the context of Old Dominion University's Radiation Protection Program, an Authorized User is person, by virtue of his/her education and/or experience, who may procure, possess and use radioactive material or radiation producing machines. Authorized Users must be approved by the Radiation Safety Committee and assume responsibility for the conduct of all persons using radioactive material or radiation producing machines under their authorization.

**Background:** Radiation from cosmic sources, naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. Background radiation does not include radiation from source, byproduct, or special nuclear materials regulated by the NRC or accelerator produced material regulated by the Commonwealth of Virginia (Virginia Department of Health).

**Bequerel (Bq):** Unit of activity equal to one disintegration per second (dps) where:  $3.7 \times 10^{10}$  Bq = 1 Ci.

**Beta Decay:** Mode of radioactive decay in which a beta particle ( $\beta^-$ ) is ejected from the nucleus of the parent atom. In beta decay, a neutron "transforms" into a proton and a beta particle. Following beta decay, the daughter has an atomic number (Z) 1 amu more than the parent and an atomic mass (A) the same as the parent.

**Bioassay:** The determination of kinds, quantities or concentrations, (and in some cases the locations) of radioactive material in the human body, whether by direct measurement (*in vivo* counting) or by analysis and evaluation of materials excreted or removed from the body (*in vitro* measurement).

**Byproduct Material:** From 10 CFR 20, any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or using special nuclear material.

**(Calendar) Quarter:** Period of time equal to three full months, ending on the last day of the third month of the specified quarter.

**Clean Area:** Areas designated and delineated *within* Restricted Areas where eating, drinking, the storage of food and applying cosmetics is allowed.

**Code of Federal Regulations (CFR):** The compilation of rules and regulations published in the Federal Register by executive departments and agencies of the federal government. Energy (including radioactive material) regulations are found in Title 10 of the Code of Federal Regulations.

**Collective Dose:** The sum of the individual doses received in a given period by a specified population from exposure to a specified source of radiation.

**Contamination:** Radioactive material in a place or places where it is not supposed to be. Contamination can either be fixed or removable.

**Count:** A pulse that has been registered by a radiation detector. Counts correspond to either an actual ionizing event or to an extraneous event or interaction (a spurious count).

**CPM:** Counts per minute.

**Critical Organ:** That bodily organ which is most susceptible to radiation damage under the specified conditions under consideration. The critical organ is normally the organ that has the highest deposition following an uptake of a radionuclide or is the organ that is most sensitive to radiation damage.

**Curie (Ci):** Unit of activity equal to the disintegration rate of 1 gram of pure  $^{226}\text{Ra}$ . One curie is equal to  $3.7 \times 10^{10}$  Bq or  $2.22 \times 10^{12}$  dpm.

**Decay-in-Storage:** Holding radioactive waste until it has decayed to background levels. Waste containing short lived radionuclides (<120 days) that has been to decayed for a minimum of 10 half-lives can be disposed of without regard for radioactivity after survey.

**Declared Pregnant Worker:** A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception for the purposes of inclusion into an embryo/fetus radiation protection program.

**Decontamination:** Reduction or removal of radioactive contamination.

**Deep Dose Equivalent (DDE or  $H_d$ ):** The dose equivalent at a tissue depth of 1 cm. ( $1000 \text{ mg/cm}^2$ ). The term applies to external exposures to the whole body.

**Derived Air Concentration (DAC):** *Derived Air Concentration:* the concentration of a radionuclide in air which, if breathed alone for one work year, would irradiate Reference Man to the limits for occupational exposure:

$$DAC = \frac{ALI}{2.4 \times 10^3 m^3}$$

$$1 \text{ DAC-hr} = 2.5 \text{ mrem} \quad \text{and} \quad 2000 \text{ DAC-hrs} = 5000 \text{ mrem}$$

**Detector:** In radiation detection, any device for converting radiation into to a signal suitable for observation and measurement.

**Disintegration:** A random, spontaneous nuclear transformation of an atom from an unstable to a (more) stable state. Nuclear disintegration is characterized by the emission of electromagnetic energy.

**Dose Equivalent ( $H_T$ ):** The product of the absorbed dose (D) and quality factor (Q) at a point or points of interest in tissue. Expressed mathematically:

$$H_T = D \times Q$$

Units of dose equivalent are the rem and the Sievert (Sv).

**Dosimeter:** A device, such as a film badge, thermoluminescent dosimeter (TLD), or pocket ion chamber which can be worn and used to measure the radiation dose a person receives over a period of time.

**Dose Rate:** The rate at which radiation dose is absorbed (e.g., rad/hr, Sv/hr, etc.).

**DPM:** Disintegrations per minute.

**DPS:** Disintegrations per second.

**Efficiency:** The number of pulses recorded by a radiation detector relative to the actual number of disintegrations of the radioactive material being measured:

$$\text{Efficiency} = \frac{\text{cpm (as measured by the instrument)}}{\text{dpm (actual number of disintegrations)}}$$

**Electron Volt (eV):** The amount of kinetic energy acquired by an electron when it is accelerated through an electrical potential of 1 volt.

**End-Window G-M:** A Geiger-Mueller detector having the window at the end of the detector.

**Exposure (H):** A measure of the number of ionizations produced in air by gamma and x-rays. The special unit of exposure is the roentgen (R).

**Exposure Rate:** The exposure per unit time (e.g., R/min, R/hr, etc.).

**Extremity:** In radiation protection, and as defined in 10 CFR 20, the hands, elbows, arm below the elbow, the feet and knees and leg below the knee.

**Eye Dose Equivalent:** Applies to external exposure of the lens of the eye, the dose equivalent to the lens of the eye at a depth of 0.3 cm (300 mg/cm<sup>2</sup>).

**Film Badge:** A package of photographic film worn like a badge by radiation workers to measure exposure to ionizing radiation. The absorbed dose can be calculated by the degree of film darkening (which is caused by the irradiation of the badge).

**Fixed Contamination:** Contamination that is not easily removed except by mechanical abrasion or physically disturbing the contaminated matrix.

**Gamma Radiation:** High energy, short wavelength electromagnetic radiation, similar to x-rays. Gamma rays have no charge and no mass and are emitted from the nucleus of some atom that has undergone radioactive decay. Gamma rays are very penetrating and are best shielded by dense materials, such as lead.

**Gray (Gy):** A unit of absorbed dose. One Gray is equal to an absorbed dose of 1 J/kg and 1 Gy = 100 rad.

**Geiger-Mueller Detector:** A gas filled radiation detector in which the applied voltage to the detector will produce the same charge per ionizing event regardless of the number of ion pairs originally formed.

**High Radiation Area:** As defined in 10 CFR 20, an area accessible to an individual in which the individual could receive a dose equivalent in excess of 0.1 rem (or 1 mSv) in one hour at 30 cm from the surface of the radiation source or from any surface that the radiation penetrates. High radiation areas are posted with the following warning:

“CAUTION, HIGH RADIATION AREA” or “DANGER, HIGH RADIATION AREA”

**Individual Monitoring:** As defined in 10 CFR 20, the assessment of dose equivalent by using devices designed to be worn by an individual. The assessment of committed effective dose equivalent by bioassay or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours. Also, an assessment of dose equivalent by using survey data.

**Individual Monitoring Device:** A device designed to be worn by a person for the assessment of dose equivalent, such as film badges, TLD's, pocket ionization chambers, and personal (lapel) air sampling devices.

**Intake:** As it applies to bioassay measurements, the quantity of radioactive material entering the body, principally by ingestion, inhalation or absorption through intact or wounded skin.

**Internal Dose:** That portion of the dose equivalent contributed by internally deposited radioactive material.

**In Vitro:** Outside a living organism.

**In Vivo:** Within a living organism.

**Ionization Chamber:** A gas filled radiation detector in which the applied voltage to the detector will produce a charge equal to the number of ion pairs originally produced.

**Ionizing Radiation:** Any electromagnetic radiation capable of displacing electrons from atoms or molecules, thereby producing ions, for example alpha, beta, x and gamma radiation.

**Isotope:** Nuclides having the same number of protons in the nucleus (the same atomic number), but differing numbers of neutrons (therefor a different atomic mass). Isotopes of the same element have essentially the same chemical properties and a particular element may have several isotopes, e.g.,  $^{234}\text{U}$ ,  $^{235}\text{U}$ , and  $^{238}\text{U}$ , etc.

**Licensed Material:** Source material, special nuclear material, or byproduct material received, possessed, used, or transferred under a general or specific license issued by the US NRC.

**Limit:** The permissible upper bounds of radiation exposure or contamination levels.

**Liquid Scintillation Cocktail:** A solution consisting of a solvent and scintillators, in which samples are placed for measurement in a liquid scintillation counter.

**Liquid Scintillation Counter:** A radiation counter which uses a liquid ("cocktail") as the scintillation media and uses light flashes to produce an electric pulse. Liquid scintillation counters are highly efficient for counting beta-emitting radionuclides, especially low(er) energy beta emitters.

**(Individual) Member of the Public:** An individual in either a controlled or unrestricted area. An individual is not a member of the public if he/she, during any period, receives an occupational dose.

**Minor:** According to 10 CFR 20, an individual under 18 years of age.

**Mixed Waste:** Waste that contains radioactive material and a RCRA hazardous chemical. Mixed waste is regulated by the US NRC for the radioactive component and the EPA for the hazardous chemical component.

**Monitoring:** The measurement of radiation levels, concentrations, surface area concentrations, or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

**Must:** In the context of Old Dominion University's *Radiation Safety Policies and Procedures Manual*, must means required.

**NIST:** National Institute of Standards and Testing.

**Occupationally Exposed Worker:** An individual who frequents a restricted area or during the course of his/her employment is assigned duties that involve exposure to radiation or licensed radioactive material.

**Photon:** A quantum of electromagnetic energy.

**(Physical) Half-Life:** The length of time it takes for a quantity of radioactive material to decay to one-half the original activity.

**Public Dose:** The dose received by a member of the public from exposure to radiation and to radioactive material released by a licensee, or to another source of radiation either within a licensee's controlled area or in unrestricted areas. It does not include occupational dose; dose received from natural background, as a patient from medical practices, or from voluntary participation in medical research programs.

**Qualified User:** An individual that has been approved by the Radiation Safety Committee to use radioactive materials under the sponsorship of an Authorized User.

**Quality Factor (QF):** A dimensionless value used in radiation protection to reflect the relative dangers of different types of radiation. Dose equivalent is obtained by multiplying the absorbed dose by the quality factor. According to 10 CFR 20, the quality factor for beta, gamma and x-ray radiation is 1, for neutrons (of unknown energy) the quality factor is 10, and for alpha radiation the quality factor is 20.

**Rad:** A unit of absorbed dose. One rad is equal to an absorbed dose of 0.01 J/kg and 1 rad = 0.01 Gy.

**Radiation Area:** An area accessible to an individual in which the individual could receive a dose equivalent in excess of 0.005 rem (or 0.05 mSv) in one hour at 30 cm from the surface of the radiation source or from any surface that the radiation penetrates and posted:

“CAUTION, RADIATION AREA”

**Radiation Producing Machine:** A system such as an x-ray machine or accelerator that produces ionizing radiation *only* when energized.

**Radiation Safety Committee:** Standing committee at Old Dominion University responsible for conduct of the Radiation Protection Program. Members are appointed by authority of the president of Old Dominion University.

**Radiation Safety Officer (RSO):** That individual responsible for executing the policies and procedures for the safe use of radioactive materials and radiation producing machines Established by the Radiation Safety Committee.

**Radionuclide:** A radioactive nuclide.

**Radioactive Decay:** A random, spontaneous nuclear transformation in which there is a change in the number of protons, neutrons or both, from an unstable to a (more) stable combination. Expressed mathematically:

$$A = A_0 e^{-\lambda t} \quad \text{or} \quad I = I_0 e^{-\lambda t}$$

**Regulated Animal Carcass:** In 10 CFR 20, an animal carcass having >0.05  $\mu\text{Ci}$  (>1.85 kBq) of either  $^3\text{H}$  or  $^{14}\text{C}$  per gram of animal tissue or any radionuclide besides  $^3\text{H}$  or  $^{14}\text{C}$ .

**Regulated Scintillation Vials:** In 10 CFR 20, liquid scintillation vials having >0.05  $\mu\text{Ci}$  (>1.85 kBq) of either  $^3\text{H}$  or  $^{14}\text{C}$  per gram of scintillation media or any radionuclide besides  $^3\text{H}$  or  $^{14}\text{C}$  in the media.

**Rem:** A unit of dose equivalent. A rem is the product of multiplying the absorbed dose (rad) times a quality factor, i.e.,  $\text{rem} = \text{rad} \times \text{quality factor}$ . One rem is equal to 0.01 Sv.

**Removable Contamination:** Contamination that is easily spread without physically disturbing the matrix it is on.

**Restricted Area:** An area, to which access is limited by the licensee for protecting individuals against undue risks from exposure to radiation and radioactive materials.

**Restricted User:** An individual who has not been approved by the Radiation Safety Committee to use radioactive materials.

**Roentgen (R):** Unit of exposure to x-rays or gamma radiation.

**Sealed Source:** Radioactive material that is encased in a capsule designed to prevent leakage or escape of the material.

**Shallow Dose Equivalent (SDE or H<sub>S</sub>):** As it applies to external exposure of the skin or extremity, the dose equivalent at a tissue depth of 0.007 cm. (7 mg/cm<sup>2</sup>) averaged over 1 cm<sup>2</sup>.

**Sharp:** In radioactive waste management, radioactive waste that has the potential to cause puncture wounds. Examples include broken glass, and Pasteur pipettes.

**Shield:** An absorber used to attenuate a beam of radiation.

**Should:** In the context of Old Dominion University's *Radiation Protection Policies and Procedures Manual*, should means recommended but not required.

**Sievert (Sv):** A unit of dose equivalent. The Sievert the product of multiplying the absorbed dose (Gray) times a quality factor, i.e., Sv = Gy × quality factor. One Sievert is equal to 100 rem.

**Smear or Swipe Survey:** Method for determining the level of removable contamination in which a swab is rubbed on a surface and the smear's radioactivity measured.

**Specific Activity:** The activity of a radionuclide per unit mass, i.e., Bq/gm. or Ci/gm.

**Stochastic Effect:** A radiation effect in which the severity of the effect does not depend on the magnitude of the dose, and the probability of the effect increases with increasing dose. Stochastic effects are all or none responses. Examples include cancer and genetic effects.

**Survey:** An evaluation of the radiological conditions and potential hazards incident to the use, transfer, release, disposal, or presence of radioactive material and other sources of radiation.

**Survey Meter:** An instrument used to locate areas of contamination, and measure exposure rates.

**TLD:** Or thermoluminescent dosimeter, a solid state radiation dosimeter that can absorb energy that may be released later, as light, by heating the dosimeter.

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

**Unregulated Animal Carcass:** In 10 CFR 20, an animal carcass having <0.05 μCi (<1.85 kBq) of either <sup>3</sup>H or <sup>14</sup>C per gram of animal tissue.

**Unregulated Scintillation Vials:** In 10 CFR 20, liquid scintillation vials having <0.05 μCi (<1.85 kBq) of either <sup>3</sup>H or <sup>14</sup>C per gram of scintillation media.

**Unrestricted Area:** An area, where access is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials.

**Uptake:** For bioassay measurements the quantity transferred from the site of the intake to the body organ(s) or tissue

**US Nuclear Regulatory Commission:** The independent civilian agency of the federal government with the authority to regulate, inspect, and oversee the nuclear industry, and the use of byproduct, source and special nuclear material.

**Virginia Department of Health (Radiological Health Program):** Agency of the Commonwealth of Virginia responsible for regulating, inspecting and overseeing the use of radiation producing machines (e.g., diagnostic x-ray machines, accelerators, etc.), and accelerator produced radioactive material.

**Whole Body:** From 10 CFR 20, and for purposes of external exposure monitoring, the head, trunk (including male gonads), arms above the elbow, or legs above the knee.

**X-Ray:** High energy, short wavelength electromagnetic radiation, similar to gamma rays. X-rays have no charge and no mass and are emitted from the electron orbitals of an atom that has undergone radioactive decay (as in electron capture decay) or as the result of charged particle interaction(s) with the atom (as with bremsstrahlung x-rays).