RADIATION SAFETY MANUAL
WRIGHT STATE UNIVERSITY
DAYTON, OHIO

(Last Updated: March 6, 2012)

Quick References:

For emergency support from the Radiation Safety Office after normal working hours, call the WSU Police Dispatcher, 937-775-2111 (or 911 on the main campus) and ask them to call Kimberly Morris or the "On-Call" EH&S representative of the Environmental Health and Safety Department.

Points of Contact:

Kimberly Morris, Radiation Safety Officer
Voice: 775-2169

Brittany Stewart, Student Radiation Safety Technician
Voice: 775-2169

Bill Palmer, Hazardous Waste Manager
Voice: 775-3788

Radiation Safety Office Web Page

Environmental Health and Safety: 775-2215

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I. ADMINISTRATION OF THE RADIATION SAFETY PROGRAM

1.0 FOREWARD

The Ohio Department of Health (ODH) governs use of radioactive materials and radiation producing devices in Ohio through the Ohio Administrative Code (OAC). Wright State University holds two licenses issued by ODH that permit use of radioactive materials. A broad scope license covers non-human use of radioactive material for research and development; the other encompasses a special medical usage. Additionally, the university possesses radiation-producing devices that are registered with ODH. The agency within ODH that handles licensing and registration issues is the Ohio Bureau of Radiation Protection (OBRP).

The University promotes the philosophy of keeping radiation doses at levels that are As Low As Reasonably Achievable (ALARA) through a comprehensive radiation safety program. The Radiation Safety Program is overseen by the University Radiation Safety Committee and implemented by the Radiation Safety Officer.

The primary objectives of the Radiation Safety Program are to:

a) Ensure that radiation doses to individuals using radioactive materials and radiation-producing devices are consistent with ALARA,

b) Ensure that radiation doses received by members of the general public from licensed and registered activities are negligible, and

c) Maintain control of radiation sources and retain documentation of their disposition.

This manual establishes the policies and procedures for use of regulated radiation sources. It faithfully complies with the rules promulgated by ODH.

Authorized and Faculty Users are issued Radiation Safety Manuals and must keep them accessible to the users under their supervision. The responsibility for safety rests with the user. Each user should read the manual and become familiar with its contents. Applying conditions under ODH rules, following procedures specific to the person's work area, and using common sense form the foundation for individual safety. Should you observe any situation or occurrence that in any way violates the objectives of the Radiation Safety Program or general safety, you must immediately bring it to the attention of your supervisor or the Radiation Safety Officer.

Radioactive materials (RM) and radiation-producing devices (RPD) provide versatile tools for research and teaching. Due to possible hazards associated with their use, several levels of responsibility have been established to manage the use and control of RM and RPD. The following pages contain information relevant to this manual and radiation source users:

Definitions and Conversion Factors | Radiation Safety Equations

Radionuclide Information | Biological Effects of Ionizing Radiation

1.1 UNIVERSITY RADIATION SAFETY COMMITTEE

The University Radiation Safety Committee (RSC) consists of the following membership. New members are approved by a majority of the standing members.

Chair - Authorized User, preferably from a biomedical science area
Representative of Management
Radiation Safety Officer
Two (or more) Authorized Users from the School of Medicine
Two (or more) Authorized Users from the College of Science and Mathematics
One (or more) Faculty User(s) for Radiation-Producing Devices

The committee is responsible to the Assistant Vice President for Research in all matters pertaining to ionizing radiation. The committee has oversight authority for radiation safety policy and management of all Authorized Users using RM and Facility Coordinators (and Faculty Users) responsible for RPD throughout the university, including its associated clinics and laboratories.

The committee exercises the authority for policy in radiation safety at the University with the objective of keeping radiation doses to students, employees, the public, and the environment at levels that are consistent with ALARA and regulatory requirements.

The committee convenes at least 4 times a year on a quarterly basis. For special business, additional meetings may be held. A quorum for each meeting consists of the chair, the management representative, the RSO, and at least one member familiar with the proposed protocol. The member familiar with the proposed protocol should represent the college or school where the protocol originated. The committee minutes summarize the deliberations, discussions, and recommended actions, and issues regarding ALARA. Each member shall receive a copy of the minutes. The RSO will hold at least one copy of the minutes for the duration of the license.

1.1.1 COMMITTEE RESPONSIBILITIES:

a) Establish a comprehensive radiation safety program for regulating the use of radiation sources consistent with good health physics practices, the philosophy of ALARA, the university's licenses and registrations, and ODH rules.

b) Develop a radiation safety manual consisting of policies and procedures that promulgate the radiation safety program.

c) Review for approval the training and experience submitted by applicants requesting to use radiation sources. Develop procedures for training various categories of workers.

d) Review for approval protocols for use of radioactive materials to ensure proper safety measures are being taken.

e) Review minor changes to user authorizations approved by the RSO, including biennial reviews of user protocols.

f) Review reports from the RSO on laboratory audits, radioactive material inventory, contamination events, personal exposures, waste disposal, and incidents.

g) Annually review the Radiation Safety Program and activities of the Radiation Safety Office for compliance with the radioactive material licenses and ODH rules.

h) Review instances of alleged infraction of radiation safety regulations. Ensure corrective measures are established and implemented under the direction of the RSO.

i) Review letters of agreement with off-site emergency response agencies.

j) Maintain a current list of committee members and their training and experience.

1.2 UNIVERSITY RADIATION SAFETY OFFICER

The University Radiation Safety Office consists of the Radiation Safety Officer (RSO) and a trained technical staff. It is located within the Department of Environmental Health and Safety (EHS). The RSO reports to the Director of EHS for all administrative matters. For matters dealing with radiation safety, the RSO reports directly to the Chair of the Radiation Safety Committee. Appointment of the RSO requires a license amendment from the ODH.

The RSO implements the policies and procedures for radiation safety, as stated in the Radiation Safety Manual, ODH rules, or directives from the Radiation Safety Committee.

1.2.2 RSO RESPONSIBILITIES:

a) Oversee all activities involving the use of radiation sources, including conducting routine and special surveys of all areas where radiation sources are present. Determine compliance with ODH rules, license conditions, and conditions of research protocols approved by the RSC.

b) Audit use and storage areas semi-annually to ensure compliance with university policies and ODH rules.

c) Conduct training programs to personnel on proper procedures for using radioactive materials, and at periodic intervals, provide refresher training.

d) Issue and process personal dosimetry, determine the need for and evaluate bioassays, monitor dosimetry results for high doses and trends, notify individuals when their radiation doses exceed ALARA levels or ODH limits, and recommend remedial actions, as needed.

e) Supervise receipt and shipment of packages containing radioactive materials.

f) Maintain an inventory of radioisotopes and ensure university possession limits are not exceeded. Maintain an inventory of RPDs.

g) Supervise and coordinate disposal of radioactive waste, including effluent monitoring.

h) Perform leak tests on appropriate sealed sources and calibration of survey meters.

i) Provide storage for radioactive material not in use, including wastes.

j) Immediately terminate the use of radioactive material that presents an unreasonable hazard to health or property.

k) Give interim approval for new protocols and authorized users pending committee approval. Subject to committee review, approve minor, non-controversial changes to protocols, such as approving individual users or changing user limits.

l) Supervise decontamination and recovery operations.

m) Maintain all records pertaining to radioactive materials, radiation producing devices, radiation protection and environmental monitoring.

n) Attend all RSC meetings and report on the activities of the Radiation Safety Office.

o) Provide consultation to personnel at all levels of employment, in matters of radiation safety.

p) Meet with new authorized users to give them a Radiation Safety Manual and discuss with them its contents and their responsibilities.

1.3 REGULATORY COMPLIANCE

ODH periodically inspects the university's Radiation Safety Program to ensure compliance with license requirements and OAC. The inspectors scrutinize records of the Radiation Safety Committee, the Radiation Safety Office, and authorized users. They will audit selected laboratories for compliance with radiation safety standards. The inspection covers such areas as training, procurement, disposal, storage, and general procedures. Severe or numerous violations of license requirements and radiation safety policies can result in loss of the license and assessment of administrative or civil penalties. Some examples of violations are unauthorized persons using radioactive materials, possessing unlicensed radioactive materials for which a license is required, or possessing licensed radioactive materials in an unlicensed location.

This manual documents the Radiation Safety Program in accordance with 3701:1-38-11 and the Quality Assurance Program in compliance with OAC 3701:1-66-04. It includes policies and procedures established by the RSC for the comprehensive implementation of the radioactive materials license and ODH rules. All persons who use radioactive materials or radiation-producing devices must be familiar with the contents of this manual applicable to them and strictly observe its provisions.

The Radiation Safety Officer maintains current copies of the radioactive materials licenses and registrations and Ohio rules. These documents are available at the Radiation Safety Office (104 HS, 775-2169). Ohio rules (3701:1-38, 40, 66) are also available at the ODH web site. *Failure to follow safety regulations and the provisions of this manual can jeopardize the authority of the University to use radioactive material and radiation-producing devices and could result in considerable negative impact on teaching and research programs, including possible loss of research funding. Violators of these regulations are therefore subject to penalties such as suspension or withdrawal of user status by the RSC. In addition, users should be aware that careless or willful violation of Radiation Safety regulations can also subject the perpetrator to civil or criminal prosecution by government agencies.*

A SAFE ENVIRONMENT DEPENDS ON YOU. Each user of radioactive material or a radiation- producing device, as well as any member of the university community, is *encouraged* to promptly report any actual or suspected infraction of these policies to a laboratory supervisor or the Radiation Safety Officer. Timely action can prevent a minor violation from escalating to a major incident. ODH "Notice to Employee" signs are posted in each use area. These forms contain the ODH phone number to call if you feel university personnel disregard your genuine safety concerns.

1.4 ALARA GOALS

The Radiation Safety Program uses the *ALARA* philosophy that states that all participants in the program (i.e., committee members, users, and the radiation safety staff) make every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical with consideration for the purpose of the activity, state of technology, economics of improvements, public health and safety, and societal benefits. ALARA action levels are listed below. Exceeding these values constitutes an occurrence that will be evaluated by the Radiation Safety Officer and reported to the Radiation Safety Committee.

Whole body (deep dose) dosimeter results:	100	mrem/quarter
Skin (shallow) dose results:	100	mrem/quarter
Extremity dosimeter results:	500	mrem/quarter
Declared Pregnant Woman:	50	mrem/quarter
Minor (less than 18 years of age):	50	mrem/quarter

Any personal contamination with radioactivity.
Any suspected intake of radioactivity.
Any radioactive contamination to an unrestricted area.
Any radioactive contamination in a restricted area that prevents use of the lab.

1.5 RADIATION DOSE LIMITS

The ODH dose limits are listed below. Exceeding any of these values requires an immediate investigation by the RSO and notification to ODH.

OCCUPATIONAL DOSE LIMITS

a) Total Effective Dose Equivalent. The Total Effective Dose Equivalent (TEDE) limit is 5 rem (50 mSv) per year for adult persons using radiation sources. The TEDE is the

sum of the deep-dose equivalent (DDE) for external exposure and the committed effective dose equivalent (CEDE) for internal exposure.

b) Committed Dose Equivalent. The Committed Dose Equivalent (CDE) limit to any individual organ or tissue must not exceed 50 rem (500 mSv) in any year.

c) Skin or Extremity Dose Equivalent. The shallow-dose equivalent (SDE) limit to the skin or extremity is 50 rem (500 mSv) per year.

d) Eye Dose Equivalent. The dose equivalent limit to the lens of the eye is limited to 15 rem (150 mSv) per year.

e) Minors. Minors (i.e., persons under 18 years of age) must receive approval from the Radiation Safety Committee to handle licensed sources. The annual exposure limits for minors are 10 percent of the above listed values.

f) Declared Pregnant Woman. A pregnant woman is subject to exposure limits listed in (a)-(d) above unless she declares her pregnancy. A "declared pregnant woman" voluntarily informs her Authorized User and the Radiation Safety Officer, in writing, of her pregnancy and the estimated date of conception. The declaration will be kept confidential. The dose to the fetus (from both internal and external sources) is then legally limited to 500 mrem equally distributed over the term of the pregnancy (i.e., 50 mrem/month). In the interest of ALARA, the Radiation Safety Committee has set the action level for exposure review for declared pregnant women at 50 mrem/quarter. Women are not required to declare their pregnancy; however, the lower dose action level only applies to declared pregnant women. The woman may revoke the declaration anytime she chooses. Documented medical proof is not required.

DOSE LIMITS FOR MEMBERS OF THE PUBLIC

a) TEDE. The TEDE to individual members of the public from licensed or registered radiation sources shall not exceed 100 mrem (1 mSv) per year.

b) Dose Rate. The dose rate in any unrestricted area from external sources shall not exceed 2 mrem/hr (20 μSv/hr).

c) Constraint Dose. Members of the public shall not be exposed (either actually or likely) to airborne radionuclides, excluding radon and its progeny, where their intake could exceed the constraint dose of 10 mrem (0.1 mSv).

1.6 DOSIMETRY ISSUANCE

1.6.1 DOSIMETER TYPES

Dosimeters are worn by persons to monitor their exposure from external sources of ionizing radiation, such as X rays, high-energy β (e.g., ^{32}P) and γ radiation emitters. Personal dosimetry does not effectively monitor doses from low-energy β radiation emitters, such as ^{3}H, ^{14}C, and ^{35}S. The types of dosimetry used at Wright State for monitoring personnel doses are whole body dosimeters, finger rings, pocket dosimeters, and posted dosimeters. All

dosimeters, except pocket dosimeters, are exchanged quarterly and processed by an accredited vendor.

a) Whole body dosimeters. Whole body dosimeters are worn on the front of the torso between the collar and the waist with the label facing outward. This dosimeter monitors the deep-dose equivalent (DDE), the shallow-dose equivalent (SDE), and the eye (lens) dose equivalent. The university uses optically-stimulated luminescent dosimeters (OSLD) or thermoluminescent dosimeters (TLD) for personal monitoring.

b) Finger rings. A finger ring monitors exposure to the hand (extremity) when handling large quantities of energetic radioactive material such as ^{32}P. They are worn on the hand predominantly exposed to radiation with the label at the palm side of the finger. The finger ring must be worn under the glove to prevent contamination. It uses a small crystal of thermoluminescent (TL) material to measure radiation dose equivalent.

c) Pocket dosimeters. Self-reading pocket dosimeters are issued from the Radiation Safety Office for short time intervals where exposure to γ or X radiation is likely (e.g., emergency situations). Pocket dosimeters are worn on the body in the same manner as whole body dosimeters. Both types, ionization chambers and solid state dosimeters, are shock-sensitive. Report immediately to the RSO if the dosimeter cannot be read, particularly if it is dropped or jarred.

d) Posted dosimetry. Some areas are posted with dosimeters to ensure that exposures to persons around the use area are consistent with ALARA and ODH regulations.

1.6.2 DOSIMETRY ISSUANCE

Dosimeters are issued when a user will work with sources that emit high-energy β, γ, or X radiation and will likely receive radiation doses as indicated below, or at the discretion of the Radiation Safety Officer. Authorized or Faculty Users can obtain dosimeters for subordinate users by having them complete a Dosimetry Issuance Card from the Radiation Safety Office. These devices are ordered from an accredited vendor and will be delivered to the appropriate user upon receipt. Users must wear their assigned dosimeter when working with energetic radioactive material. Never wear somebody else's dosimeter.

a) *Adult User*. When an adult will likely receive an dose of 500 mrem/year (5 mSv/year) deep dose equivalent, 5 rem/year (50 mSv/year) shallow dose equivalent to the skin or extremities, or 1.5 rem/year (15 mSv/year) eye dose equivalent.

b) *Declared Pregnant Woman*. When a declared pregnant woman is likely to receive 50 mrem (0.5 mSv) over the gestational period.

c) *Minors*. When a minor (i.e., person under 18 years of age) is likely to receive one-tenth of the adult user values listed in section (a) above..

d) *High Radiation Area.* Anyone entering a high radiation area (3701:1-38-15).

1.6.3 LOST OR DAMAGED DOSIMETERS

Report to the Radiation Safety Office when a dosimeter is lost and cannot be found. The RSO should estimate the dose for that dosimetry period. **Inform the RSO anytime you suspect that your dosimeter may have been tampered with or exposed to electrical shock, caustic chemicals, or high temperatures.** The RSO will track that dosimeter for anomalous readings.

1.6.4 INTERNAL EXPOSURE MONITORING

Internal exposure monitoring is required for a (an):

a) *Adult* when he/she is likely to have an intake in one year in excess of 10% of the applicable ALI for ingestion or inhalation.

b) *Minor or Declared Pregnant Women* when he/she is likely to have an intake in one year of a committed effective dose equivalent more than 50 mrem (0.5 mSv).

1.6.5 DOSIMETRY RECORDS AND REPORTS

The RSO reviews dosimetry results upon receipt for elevated dose levels. Dosimetry records must be retained for the duration of the license. Any estimated exposures or results from internal monitoring remain part of the record. Any dose exceeding the ALARA action level must be investigated and reported to the Radiation Safety Committee. Reports to the Radiation Safety Committee or Ohio Department of Health concerning dose to an individual will also be provided to the affected person.

a) Annual Dose Reports. Each year, persons monitored for radiation dose shall be informed of their dose, in writing.

b) Dose History. At the request of an individual, the RSO will send a report of dose during the current year within 30 days of receipt of the request.

c) Dose Estimates, Intake Assessments. Situations that require the RSO to estimate doses or evaluate potential intake of radionuclides will be documented.

II. USE OF RADIOACTIVE MATERIALS

2.1 AUTHORIZED USER

An Authorized User (AU) is a departmentally affiliated member of Wright State University, including adjunct faculty, authorized by the Radiation Safety Committee to use radioactive material (RM) independently and supervise subordinate users (i.e., Individual, Visitor, and Supervised Users). The use shall fully comply with research protocols approved by the committee. An AU is responsible for the safe use and storage of radioactive materials in his/her laboratory, including usage by anyone under his/her direction and protection of non-users. Additionally, the AU shall ensure that subordinate users have proper training to safely perform each assigned task and respond appropriately to emergency situations. Research protocols must be submitted for RSC approval before using RM.

2.1.1 AUTHORIZED USER QUALIFICATIONS

A prospective Authorized User must apply to the RSC for approval. The applicant shall submit his/her training and experience on Form RSO1. The AU must:

a) Possess at least a bachelor's degree in the physical or biological sciences;

b) Have 40 hours of training and experience using radioactive materials. The experience should be using material similar to that proposed for use with regard to the laboratory techniques, possible hazards, and necessary precautions.

c) Possess a Radiation Safety Manual and review the manual with the RSO, paying close attention to AU responsibilities and other issues relevant to radiation safety.

The AU's experience with radioactive materials should be reasonably current. The Radiation Safety Committee will judge the adequacy and recentness of experience on a case-by-case basis.

An applicant who is otherwise qualified may gain experience using radioactive material as an Individual User under the supervision of a qualified Authorized User. Upon written recommendation by the supervising Authorized User, the committee may upgrade the applicant's status to Authorized User.

2.1.2 AUTHORIZED USER RESPONSIBILITIES

a) Order and possess only the types and quantities of radioactive materials for which the AU has approval by the RSC. Obtain approval from the Radiation Safety Office before procurement.

b) Ensure that all personnel who enter the AU's laboratory adhere to protocol specifications, the safety rules and regulations recorded in this manual, and any other communications from the RSO or RSC.

c) Instruct subordinate users on safe practices and responsibilities in the lab. The instruction must include relevant sections of the Radiation Safety Manual. Training documented on Laboratory Hazard Instruction Form (or equivalent) is required for persons who are likely to receive a radiation dose of 100 mrem per year or more.

d) Plan and rehearse procedures for RM use to recognize equipment needs, keep radiation exposures As Low As Reasonably Achievable (ALARA), and prepare for unforeseen situations.

e) Keep protocols current as procedures and users change. Send updated information to the RSO by memorandum. Review all current protocols for accuracy and any change that may influence radiation safety at least biennially (every two years).

f) Restrict usage of radioactivity to only those materials and users who have received training commensurate with the proposed usage.

g) Inform the RSO immediately of radiation related accidents, spills that limit use of the lab or expand into unrestricted areas, personal contamination, or loss of radioactive materials, even if these incidents occur after normal working hours.

h) Ensure subordinate users have appropriate dosimetry devices (OSLDs, finger rings) and check regularly on their use. Also, coordinate with the RSO to ensure that bioassays are performed when necessary.

i) Maintain proper records of use, transfer, and disposal of RM.

j) Correct and inform the RSO of any observed deficiencies or potential problems related to radiation safety.

k) Utilize safe measures to minimize radioactive waste. Minimize the storage of RM in laboratories by experimental design and purchase management.

l) Adopt adequate measures for security and control of RM against tampering, loss, theft or unauthorized removal from laboratories or storage areas.

m) Ensure the laboratory use and storage areas and containers are properly labeled.

n) Coordinate the activities of housekeeping and physical plant staff to assure their protection while they are providing services in restricted use and storage areas.

o) Survey for contamination by performing swipes for removable contamination and monitoring with a survey meter at required or appropriate intervals after using unsealed radioactive materials.

p) Decontaminate after spills that occur within areas of responsibility and report such incidents to the RSO.

q) Ensure the Radiation Safety Office surveys all equipment and lab spaces that may be contaminated before they are released for repair, disposal, or unrestricted use.

r) Arrange for a qualified AU to assume responsibility for ordering materials and general supervision of projects and users during prolonged absences, e.g., sabbatical. Inform the Radiation Safety Officer of plans and arrangements.

s) Keep the Radiation Safety Manual accessible to users.

2.2 INDIVIDUAL USER

An individual user (IU) is a departmentally affiliated member of the university, who uses radioactive materials under the direction of an Authorized User with a limited degree of supervision. The IU is responsible for the safe performance of his/her own activities. The IU can assist the AU in training new users in the lab. An AU must apply to the Radiation Safety Committee to add a person to his/her protocol as an Individual User. The RSC grants approval of IU status based on education and experience and recommendation from the Authorized User. Subject to RSC review, the RSO may approve persons who are clearly qualified.

2.2.1 INDIVIDUAL USER QUALIFICATIONS

Applicants With Prior Experience. The AU must:

a) Submit the prospective IU's training and experience on Form RSO1 to the RSO.

b) Provide specific training on laboratory procedures, radiation hazards, rules and regulations, and user responsibilities. This training must be documented on the Laboratory Hazard Instruction form (or equivalent) if the person will likely receive a radiation dose of 100 mrem/year or more. Completion of the *Safe Use of Radioactive Material*s course is encouraged.

c) Provide direct (observed) supervision during all use procedures until the AU is confident that the prospective Individual User can work independently. The period of supervision should be commensurate with the person's experience.

d) Add the IU to the AU's authorization by memorandum to the RSO.

Applicants Without Experience. The AU must:

a) Ensure the prospective IU completes the *Safe Use of Radioactive Material*s course.

b) Provide specific training on laboratory procedures, radiation hazards, rules and regulations, user responsibilities, and emergency procedures. This training must be documented on the Laboratory Hazard Instruction form (or equivalent) if the person will likely receive a radiation dose of 100 mrem/year or more.

c) Provide direct (observed) supervision during all use procedures until the AU is confident that the prospective Individual User can work independently. The period of supervision should be commensurate with the person's ability.

d) Add the IU to the AU's authorization by memorandum to the RSO.

2.2.2 INDIVIDUAL USER RESPONSIBILITIES

a) Use only the types and quantities of RM covered by research protocols approved by the RSC.

b) Adhere to the safety rules and regulations recorded in the Radiation Safety Manual and any communications from the RSC.

c) Practice new techniques and procedures before using radioactivity to keep radiation exposures ALARA and to identify possible problem areas that may hamper safety or research outcome.

d) Inform the AU and RSO immediately of radiation related accidents, spills, personal contamination, or loss of radioactive materials, even if these incidents occur after normal working hours.

e) Wear issued radiation dosimeters, when appropriate. Keep the dosimeters accessible to the Radiation Safety Office. Undertake bioassays, as necessary.

f) Inform the AU of observed deficiencies or potential problems related to radiation safety. Inform the RSO if timely corrective action is not initiated.

g) Maintain adequate measures for security and control of RM against tampering, loss, theft or unauthorized removal from laboratories or storage areas.

h) Survey for contamination at required or appropriate intervals after using unsealed radioactive materials.

i) Assist AU with day-to-day responsibilities, such as keeping complete and accurate records, decontamination of minor spills, labeling use areas and equipment, and keeping other personnel aware of use areas and potential hazards in the lab.

j) Employ general radiation safety precautions.

2.3 VISITOR USER

A Visitor User seeks to collaborate with an Authorized User on a project usually less than several months utilizing radioactive materials, but is *not* a member of the university community. The sponsoring Authorized User will submit a Visitor User Application (Form RSO7) to the Radiation Safety Committee for approval. The visitor will work directly under the Authorized User and cannot supervise any other users in the lab.

2.3.1 VISITOR USER QUALIFICATIONS

Applicants With Prior Experience. The AU must:

a) Submit a Visitor User Application form for the prospective VU. Attach documentation of training and Experience (Form RSO1) documenting the person's training and experience.

b) Provide specific training on laboratory procedures, radiation hazards, rules and regulations, user responsibilities, and emergency procedures. This training must be documented on the Laboratory Hazard Instruction form (or equivalent) if the person will likely receive a radiation dose of 100 mrem/year or more. Attendance of the *Safe Use of Radioactive Material*s course is encouraged.

c) Provide direct (observed) supervision during all use procedures until the AU is confident that the prospective Visitor User can work independently. The period of supervision should be commensurate with the person's experience.

Applicants Without Experience. The AU must:

a) Submit the Visitor User Application form.

b) Provide specific training on laboratory procedures, radiation hazards, rules and regulations, user responsibilities, and emergency procedures. This training must be documented on the Laboratory Hazard Instruction form (or equivalent) if the person will likely receive a radiation dose of 100 mrem/year or more.

c) Provide direct (observed) supervision during all use procedures until the AU is confident that the prospective Visitor User can work independently. The period of supervision should be commensurate with the person's background and ability.

d) Attendance of the *Safe Use of Radioactive Material*s course is required.

2.3.2 VISITOR USER RESPONSIBILITIES

a) Use radioactive materials only as directed by the Authorized User.

b) Employ all general safety precautions.

c) Use only equipment and materials for which specific and instruction and permission has been given.

d) Properly wear dosimeter. Return dosimetry, if issued, to the RSO at the termination of the project.

2.4 SUPERVISED USER

A Supervised User (SU) is a member of the university who has no previous training or experience using radioactive materials; therefore, the SU must always be directly observed and supervised by an Authorized User or experienced Individual User. An SU may be a student who uses radioactive material as part of an academic course or laboratory setting or as an interim process to become an Individual User.

2.4.1 SUPERVISED USER QUALIFICATIONS. The AU:

a) Will provide specific training before the initial use on laboratory procedures, radiation hazards, rules and regulations, user responsibilities, and emergency procedures. This training must be documented on the Laboratory Hazard Instruction form (or equivalent).

b) Will ensure all use is directly observed and supervised personally or by an IU familiar with the project.

c) Should provide the names of SU to the Radiation Safety Officer either individually or by class roster.

2.4.2 SUPERVISED USER RESPONSIBILITIES

a) Use radioactive materials only under the direction and observation of the AU.

b) Employ all general safety precautions.

c) Use only equipment or materials for which specific instruction and permission has been given.

d) Return dosimetry, if issued, to the RSO at the termination of the project.

2.5 TRAINING FOR NON-USERS

People who enter radiation use areas, but are not approved to use radioactive materials (such as students, maintenance or custodial personnel, and members of the general public) must receive instruction in accordance with OAC 3701:1-38-10(B) if they will likely receive from lab sources a total effective dose equivalent (TEDE) of 100 mrem (1 mSv) in a year. The radiation safety program includes training to Environmental Health and Safety staff, animal caretakers, custodians, and maintenance workers. The Laboratory Hazard Instruction form provides acceptable criteria and documentation to fulfill this requirement.

2.6 EXPERIMENTAL PROTOCOLS

2.6.1 PROTOCOL APPLICATIONS

A protocol is a written communication between an Authorized User and the Radiation Safety Committee that presents how the radioactive material will be used and describes the safety measures that will be taken. The Application to Use Radioactive Materials (Form RSO3) must be reviewed by the RSO and approved by the Radiation Safety Committee *prior to using* the materials. Interim approval may be granted by the RSO for protocol applications that are clearly compliant with this section of the manual. The RSO will discuss with the Chair of the Radiation Safety Committee any problems or questionable areas regarding interim approval. The protocol application must show that anticipated radiation exposures or any release of radioactive material is consistent with ALARA. If animals will be used in the study, see the Animal Use section.

The Radiation Safety Committee will review the protocol, specifically considering the adequacy of facilities and equipment to be used; operating, handling, and emergency procedures; and training and experience of proposed users. The submitted protocol for use of radioactive materials will address the following topics. Consult with the Radiation Safety Officer (775-2169) if you have questions regarding the protocol application.

a) *list all isotopes* needed to complete the study, *compounds* to be used, and the *total activity* required for each isotope. The compound may be specific (e.g., ^{32}P-[dATP, dCTP]) if the study is limited to those materials; or general (e.g., nucleotides) if the study will use many similar materials. The activity indicated is the most that may be present in the lab at any one time, including that in use, storage, and waste.

b) *list the personnel involved*, include forms (Form RSO1) for Individual Users who have previous training and experience or ensure they have attended the *Safe Use of Radioactive Materials* course.

c) *list intended use and storage areas.*

d) *address specific safety issues*, such as dosimetry, bioassays, personnel protective measures and equipment, contamination prevention and monitoring, and ventilation requirements.

e) *briefly describe the investigation*, including procedures and precautions pertinent to use, disposal, and disposition of radioactive materials. Consider:

   (1) Estimate the activity that will be used each day the experiment is run.
   (2) Estimate the activity that will be picked up by the Radiation Safety Office or discharged into the sewer.
   (3) Do you plan to use animals? For ^{14}C or ^{3}H, will the activity in animal carcasses exceed 0.05 μCi/gram of animal tissue?
   (4) Indicate the brand of scintillation fluid you will use.
   (5) Is there a potential for an airborne hazard or contamination of a vacuum system?
   (6) Will you generate mixed waste?

2.6.2 PROTOCOL CHANGES

a) Minor Changes. Examples of minor protocol changes include adding or deleting an Individual User, changing the possession limit of a radionuclide, or adding an isotope or compound to a protocol that does not involve procedural changes. Minor changes require a memorandum from the Authorized User to the RSO indicating the change and briefly explaining the reason. The RSO may approve the change, subject to review by the Radiation Safety Committee.

b) Significant Changes. Protocol changes where the procedures or project scope differ significantly from current approved protocols require the submission an additional protocol application form (Form RSO3). The RSO may provisionally approve the change, pending final approval by the Radiation Safety Committee.

c) Protocol Renewal. Biennially, Authorized Users must review their protocols to ensure the information is current and accurate. Authorized Users are encouraged to compare their current laboratory procedures, materials used, and personnel against protocol records. The RSO summarizes the protocol information to facilitate the review.

2.6.3 PROTOCOL SUSPENSION

Authorized Users who are not currently using radioactive materials, but may do so in the foreseeable future may place their protocol in suspension by informing the RSO in writing. Radioactive materials should be removed from the lab and the lab released for unrestricted use pending continued usage. The Authorized User must notify the RSO when radioactive material usage will be resumed.

2.6.4 PROTOCOL TERMINATION

Authorized Users who plan to discontinue using radioactive materials or end their university affiliation must terminate their appropriate protocols. The AU must:

a) inform the RSO of termination plans,

b) assure that facilities and equipment are free from contamination,

c) return all remaining RM and dispose of wastes to the Radiation Safety Office,

d) return the Radiation Safety Manual, dosimetry, survey meters, radiation protection equipment, and shielding devices to the Radiation Safety Office, and

e) schedule a final laboratory radiation survey and bioassay where appropriate.

2.7 GENERAL PRECAUTIONS WHEN USING RADIOACTIVE MATERIALS

- ☐ Wear a lab coat, gloves, and safety glasses, as required, while handling unsealed radioactive materials.
- ☐ Monitor the work area and gloves regularly to identify contamination and prevent its spread.
- ☐ Do *not* eat, drink, or apply cosmetics in areas where radioactive materials are handled. WSU prohibits smoking in all buildings.
- ☐ Keep radioactive work separated from other work, preferably by maintaining areas used solely for radioactivity.
- ☐ Use *time, distance,* and *shielding and contamination control* to keep your dose as low as reasonably achievable (ALARA).
- ☐ Work over a spill tray in a certified ventilated enclosure, especially when using large quantities (> 1 mCi) of radioactive materials or compounds that vaporize easily (e.g., ^{3}H-water and ^{125}I-sodium iodide).
- ☐ Use the minimum quantity of radioactivity needed to meet the objectives of the experiment.
- ☐ Never handle unsealed radioactive materials with open cuts or breaks to the skin.
- ☐ Use tongs or other remote handling equipment to minimize exposure to extremities.
- ☐ Never pipette by mouth.
- ☐ Properly wear dosimetry, if issued, for all radioactive work.
- ☐ Wash your hands and, if applicable, monitor yourself before leaving the lab.
- ☐ Document radioactive material usage and waste disposal on inventory cards.
- ☐ Label radioactive containers clearly, indicating nuclide, activity, compound, and date.
- ☐ Dispose of radioactive waste according to provisions of the experimental protocol, *never in ordinary trash*.

2.8 EXTERNAL EXPOSURE PROTECTIVE MEASURES

2.8.1 TIME

Radiation dose can be decreased by reducing the amount of time users spend working with high-energy beta (β) and gamma (γ) emitting radionuclides. Users should practice new procedures *without radioactivity* to become familiar with the steps involved and to identify

potential problem areas. Never rush while working with radioactive materials. Hurrying through a procedure can lead to a spill or accident that may actually increase dose.

2.8.2 DISTANCE

Radiation intensity decreases inversely with the square of the distance ($1/d^2$) when the source is small compared to the distance. The dose from low-energy beta emitters (e.g., ^{3}H and ^{14}C) is zero at 10 to 20 cm. For high-energy β and γ emitting radionuclides, remote-handling devices (e.g., tongs or forceps) can reduce radiation dose to hands and fingers when handling containers holding large activities. Practice using tongs without radioactivity to become comfortable working with the tools. Store radioactive materials away from personnel, lab benches, or desks where lab personnel may spend a lot of time.

2.8.3 SHIELDING

Attenuating material placed in the radiation path can effectively reduce external exposure. The amount of shielding needed is determined by the type and energy of radiation, composition and thickness of shielding material, distance from the source, time spent in the work area, and acceptable level of dose reduction. The effectiveness of the shielding should be verified using a survey meter. The exposure rate to an unrestricted area and at the user's position should be reduced to 1 mrem/hr or less for long procedures. The exposure rate in an unrestricted area must not exceed 2 mrem/hr.

Low-energy beta (β) radiation (e.g., ^{3}H and ^{14}C) has a very short range in material; therefore additional shielding is not necessary. Shield high-energy beta emitters (e.g., ^{32}P) with 3/8-inch or more of a low-atomic-number material, such as plastic. Eyewear, such as goggles will substantially reduce ocular exposures and prevent eye contamination. Gamma emitters must be shielded with high-density materials, such as lead. The Radiation Safety Office will assist in the design of shielding upon request.

2.8.4 PRECAUTIONS WHEN USING ^{32}P IN MILLICURIE AMOUNTS

Handling millicurie quantities of ^{32}P when unshielded can expose an investigator to very large dose rates, especially to extremities. One mCi of ^{32}P in one ml of fluid yields a dose rate of about 2 rem/hour at 15 cm above the mouth of an open vial. This dose rate will increase with increasing activity. The researcher should be aware of the potential high dose rates and be vigilant toward employing protective measures and ALARA. The bremsstrahlung dose rates are unimportant compared to the unshielded beta dose rates. At 15 cm from a 40-mCi vial, the dose rate from bremsstrahlung may be 0.004 rem/hour, where the dose rate from beta radiation may be 50 - 100 rem/hour.

a. Extremity dosimetry and an operational survey meter are required. Place the extremity dosimeter under the glove and on the finger most highly exposed. Double gloves are encouraged.

b. Pipetting must take place behind a 3/8-inch plastic shield to protect the head and torso. Efforts should be made to position the stock vial and final container to minimize travel distance and time. Use a tray to transport petri dishes. Cover the dishes to

further reduce personal dose and prevent spillage.

c. An uncollimated liquid-filled pipette tip or petri dish can contribute to dose to the hands. A significant depth of liquid in the petri dish and covers can partially shield the beta dose.

d. For multi-millicurie quantities, the pipette should have a 3/8-inch plastic plate attached to the grip to shield the hand. The shield should be large enough to keep the hand and forearm out of the beam of the stock vial. Once pipetting is done, the used tip should go directly into a shielded waste container.

e. Remove the pipetting hand out from the beam of the stock vial as soon as possible after removing the pipette tip. Remove and replace the stock vial cap using tongs. Replace the cap immediately after pipetting.

f. Monitor your gloves frequently during use. If contamination is found, remove the gloves immediately and dispose of them properly. Adjust your technique to eliminate the cause. Do not accept routine glove contamination. The dose rate from ^{32}P directly on the skin is about 8800 mrem/hour per $\mu Ci/cm^2$. A layer or two of gloves will not decrease that dose rate by much.

g. Monitor your person, including your gloves, face, lab coat sleeves and front, and shoes and the use area for contamination before leaving the work area. Survey for removable contamination as required.

2.9 INTERNAL EXPOSURE PROTECTIVE MEASURES

Radioactive materials are of most concern when they become internally deposited in the body. Radioactive substances can enter the body by inhalation of airborne contamination, oral intake, or absorption through the skin. By working in a well-ventilated space, wearing personal protective clothing, using good work habits, and effectively controlling radioactive materials, internal exposures should not occur.

2.9.1 PERSONAL PROTECTION

Good, basic laboratory technique is the primary defense against contamination and internal exposure. User attire consists of plastic gloves and a lab coat. Safety goggles must be used when required by the university's Chemical Hygiene Plan. Cover open wounds or cuts to avert this route of entry. Do not eat, drink, smoke, or apply cosmetics in the use area. Monitor or change gloves frequently during experiments using unsealed radioisotopes. When using a high-energy β emitter, monitor gloves, the lab coat, and the use area with a survey meter after the experiment is completed. Surveys of other places (e.g., face, shoes, desk, or phone) may also be necessary if contamination is found. Be sure to wash your hands soon after removing gloves.

2.9.2 PROTECTION FROM AIRBORNE CONTAMINANTS

Procedures that can produce contaminated aerosols, dusts, or gases shall be conducted in a fume hood that has been approved by the Environmental Health and Safety Department within the past 12 months. Vials containing tritiated water or large amounts (i.e., greater than 10 μCi) of an unlabeled radioiodine shall be opened in a certified fume hood. When applicable, traps and filters should be incorporated in the experimental setup to ensure that environmental releases are ALARA and prevent contamination of vacuum systems.

Radioactive gases or materials with gaseous radioactive daughters must be stored in gas-tight containers situated in a fume hood or an approved area having adequate ventilation.

2.9.3 ANNUAL LIMIT ON INTAKE (ALI)

Proper use of protective measures should prevent any personal contamination or internal exposure to radioactive materials. The annual limit on intake (ALI) is the regulatory limit for radioactive material taken into the body by a user in one year. The ALI is based on the intake of a radionuclide (in μCi) that would result in a committed effective dose equivalent (i.e., cumulative exposure) of 5 rem (0.05 Sv) or a committed dose equivalent (i.e., organ or tissue dose) of 50 rem (0.5 Sv). The Radionuclide Information site lists the ALI for several licensed radionuclides.

2.10 WORK AREA PROTECTION

Users must take precautions to prevent their work areas from becoming contaminated or spreading the problem should contamination occur. Work surfaces should be covered with plastic-backed absorbent paper to minimize the potential of contaminating bench surfaces. Material usage should be performed over small sections of absorbent paper or a spill tray (lined with absorbent paper) to contain spills as well as reduce the waste volume. Use and storage areas should be concentrated in a remote part of the lab to reduce the transport of materials. Unsealed radioactive liquids should be transported on a spill tray, or otherwise secured against spillage.

Users shall ensure that vacuum systems remain free of contamination by demonstrating that evacuated gases are not contaminated. Radioactive gases must be passed through a liquid trap (or other effective means) before entering a vacuum pump or the university vacuum system. Separate vacuum pumps should be vented into an exhaust hood when the experiment produces radioactive gases or aerosols. The vacuum pump oil should be periodically checked for contamination.

Good housekeeping can mitigate mishaps. Users should maintain clean, orderly labs to promote a safe environment.

Only "hot" sinks (i.e., sinks designated for radioactivity) shall be used to dispose of liquid waste or wash contaminated laboratory equipment. After usage, sinks should be copiously flushed. Do not fill containers for consumption from a hot-sink tap.

2.11 PURCHASING RADIOACTIVE MATERIALS

The acquisition of radioactive material requires approval from the responsible Authorized User and the Radiation Safety Office. The AU must ensure that he/she is permitted to have the material and that possession limits will not be exceeded. Endorsement by the Radiation Safety Office allows the RSO to check the requested material and amount against the Authorized User's approval and prepare for receipt. Approval from the Radiation Safety Office may be obtained by written authorization, phone, or e-mail.

Purchase order forms must include following information: (a) isotope, (b) activity, (c) chemical compound, (d) the words "RADIOACTIVE MATERIAL", (e) the Authorized User's signature, and (f) the signature of a Radiation Safety representative.

All packages containing radioactive material must be delivered to the Radiation Safety Office (example delivery address: "Radiation Safety Officer, 104 Health Sciences Bldg."), unless alternative methods for receipt have been approved by the RSO. Users are urged to avoid having deliveries made when the Radiation Safety Office is normally closed (i.e., evenings, weekends and holidays). Coordination with the Radiation Safety Office is required if the delivery of a package is expected outside of normal working hours.

2.12 RECEIPT OF RADIOACTIVE MATERIALS

2.12.1 RECEIPT BY RADIATION SAFETY OFFICE

All packages containing radioactive materials will be delivered unopened, to the Radiation Safety Office (loading dock, Health Sciences Building or 141B Biological Sciences Building). Personnel from the Radiation Safety Office will open and inspect the package, perform required surveys [OAC 3701:1-38-18 (F)], and complete the Radioactive Materials Receipt Form. Following clearance, the Radiation Safety Office will add the material to the University inventory and deliver the package to the appropriate user. Records of receipt must be retained for three years.

2.12.2 DIRECT RECEIPT

Arrangements for the direct receipt of radioactive material by an Authorized User will be based on logistical considerations or the need to preserve physical, chemical, or biological characteristics. The recipient must promptly receive the package using the following procedures. Documentation of results must be retained for three years. The AU should send a copy of the receipt document to the Radiation Safety Office.

2.12.3 PACKAGE RECEIPT PROCEDURES:

a) Visually inspect the package for any sign of damage or degradation (e.g., wetness not due to precipitation, crushed or severely punctured container).

b) Wear gloves. For high-energy β or γ emitters, also wear dosimetry.

c) If the package is labeled (i.e., White I, Yellow II, or Yellow III) *or* damage is suspected, the following surveys ***shall*** be done within 3 hours of arrival (or by 10 a.m. if the package arrives before normal working hours). Surveys are optional for undamaged packages without a transportation label (e.g., Limited Quantity).

(1) *Swipe Survey*. Monitor (i.e., swipe) the external surfaces of the package for removable contamination. Swipe an area of 300 cm^2 with a filter pad, or similar absorbent material, using moderate pressure. Count the swipe using a liquid scintillation counter. For γ emitting radionuclides, swipes can be counted on a gamma-well counter.

Action Level: Swipe survey is 200 dpm or greater
Legal Limits [49CFR173.443]:
(a) 22 dpm/cm^2 (6600 dpm/300 cm^2) for β-γ emitters and low toxicity α emitters, such as natural thorium or uranium, ^{238}U, or ^{232}Th.
(b) 2.2 dpm/cm^2 (660 dpm/300 cm^2) for other α emitters.

(2) *External Radiation Levels*. Monitor the surface of the package and at one meter with a radiation detector. Record readings in mrem/hr (or mSv/hr).
Action Levels/Legal Limits [49CFR172.403]:
(a) White I: <0.5 mrem/hr on the package surface.
(b) Yellow II: ≤50 mrem/hr on the surface or ≤1 mrem/hr at one meter.
(c) Yellow III: ≤200 mrem/hr on the surface or ≤10 mrem/hr at one meter.

d) Ensure that the container label and shipping manifest agree with purchase order.

e) Survey the packaging material (e.g., the cardboard box and styrofoam insert). If negative for contamination, remove or obliterate all markings indicating radioactivity and dispose as normal trash. Styrofoam containers for some companies may be shipped back to the manufacturer if not contaminated.

f) Notify the RSO immediately if :
(1) the package appears damaged;
(2) the security seal on the outer package is broken;
(3) a labeled package is delivered to the wrong place;
(4) the package contents do not agree with the packing slip; or
(5) the swipe survey or external radiation levels exceed action levels.

g) Send a copy of the completed Receipt Form and Inventory Card to the RSO.

2.13 LOCATIONS OF USE AND STORAGE

2.13.1 LICENSED LOCATIONS

The university's license with ODH applies to all licensed radioactive materials on the main campus, Cox Institute, Buildings 307 and 315 at the Veterans Affairs Medical Center in Dayton, or other places specifically listed on the license. Possession of licensed radioactive material at any other location constitutes a violation of the ODH license.

2.13.2 APPROVED USE LOCATIONS

Radioactive material shall be used or stored only in areas specified in the Authorized User's application for use (Form RSO3), as approved by the Radiation Safety Committee. The laboratory must be properly equipped for the proposed use, such that assurances for supervision, safety, and security are present. Suitable provisions shall be made to prevent inadvertent exposures to students, staff or the public; releases of radioactive material; and loss, unauthorized removal, or theft of materials. All transfers or shipments of radioactive material must comply with the university transportation policies.

Research laboratories should consolidate use or storage areas for radioactive material to minimize the movement of materials through the lab. Use areas should be reasonably isolated from other projects not using radioactive material and clearly marked with "Caution - Radioactive Material" tape.

The RSO maintains a list of current and former use locations as required by ODH for decommissioning. This list is updated at least every two years.

2.14 INVENTORY OF RADIOACTIVE MATERIALS

2.14.1 INVENTORY CARDS

The Radiation Safety Office initiates and distributes yellow *Inventory of Radionuclides* cards (Form RSO 10) with each unsealed source of radioactive material received. Continued maintenance of these cards with current information on use and disposal is necessary for keeping the university's inventory current and accurate. When all the material is disposed, the user indicates the distribution of the waste and returns the card to the Radiation Safety Office.

2.14.2 CENTRAL INVENTORY

The Radiation Safety Officer maintains a computer inventory of radioactive materials. Semi-annually the RSO performs an inventory of all radioactive materials to ensure the central inventory is up-to-date and that all sealed sources are accounted for.

2.14.3 INTER-LABORATORY TRANSFER OF RADIOACTIVE MATERIALS

Transference of radioactive materials to another Authorized User requires that the recipient be authorized to possess the type and quantity of material being provided. The RSO must be informed so that the inventory can be updated with the new location and owner. The transfer may involve consigning all (full consignment) or part (partial consignment) of stock materials. The below procedures are guidelines that fulfill the requirement of being able to track the material. Other means may be applied providing that Authorized Users only possess materials for which they are approved, the central inventory is updated, and the new user has a way to document his/her usage and disposal.

When transporting radionuclides between labs, users will take precautions to protect unrestricted areas against contamination. Unsealed materials must be contained in a leak-proof receptacle (e.g., a sealed plastic bag) that would not likely break if accidentally dropped.

a) Procedures for Full Consignment of a Radioisotope:

(1) Ensure the recipient is approved to possess the material.
(2) On the *Inventory of Radionuclides* card issued for that material:
    (a) Mark a single line through the name of the "principal investigator" and write the name of the receiving Authorized User.
    (b) On the next available "New balance" line, write the "Quantity" (activity) transferred, "Date" of transfer, and "Remarks" indicating the transfer (e.g., Transferred to Dr. X in 459 BH).
    (c) Give the material and revised card to the recipient AU.
(3) Inform the RSO of the transfer by phone or e-mail. Send the RSO a photocopy of the revised card. The RSO will update the central inventory with the new responsible user and location.

b) Procedures for Partial Consignment of a Radioisotope:

(1) Ensure the recipient is approved to possess the material.
(2) On the next available "Transferred" line on the *Inventory of Radionuclides* card, write the "Quantity" (activity) transferred, "Date" of transfer, and "Remarks" indicating the transfer (e.g., Transferred to Dr. X, 459 BH).
(3) Make two copies of the card. Line out the former responsible user and add the name of new Authorized User to both copies.
(4) On the original card, enter the activity remaining on the next "New balance" line.
(5) Provide one copy of the card to the new Authorized User and one to the RSO.
(6) The RSO will update the central inventory.

2.15 TRANSPORT (SHIPMENT) OF RADIOACTIVE MATERIAL

Packages of radioactive material shipped over public roads must comply with regulations of the Department of Transportation (49 CFR 172, 173) and ODH rules. These regulations specify numerous requirements, such as: package labeling, manifests, contamination surveys, exposure rate measurements, and hazardous materials training. To ensure compliance with these requirements, ***only the Radiation Safety Officer or qualified Radiation Safety Office personnel can authorize the shipment of radioactive materials over public roadways.***

When radioactive materials are to be shipped from the university, the Radiation Safety Office will inspect the contents and packing, check for contamination and radiation levels, and ensure all other regulatory requirements are met. The Authorized User must provide the complete name and address of the intended recipient including the delivery address for the receiving Radiation Safety Office or department. A copy of the recipient's NRC or agreement state license must be obtained to ensure they can possess the material. Transport by private conveyance is prohibited, unless approved by the RSO.

2.16 SECURITY

The loss or theft of radioactive material can result in a violation of the ODH license and possibly personal injury. Licensed radioactive materials in storage or use must be secured

against tampering, loss, unauthorized removal and theft. **The room where materials are used or stored must be locked whenever a user is not present.** Radioactive materials secured in a locked container (e.g., freezer) achieve this requirement when the above measures cannot be met. The University Radiation Safety Committee may require additional security measures or allow alternate security methods, depending on the specific situation. Lab personnel should assist unfamiliar persons who enter the lab and ensure they do not enter an area where they would likely receive a dose of 100 mrem in a year without radiation safety training. Food and beverages must not be stored with licensed radioactive material. Immediately inform the RSO if radioactive material is discovered missing.

2.17 POSTING / LABELING WARNING SIGNS

Warning signs and labels heighten the awareness of persons who may enter the lab. Labels mark areas and equipment that may be contaminated and provide a constant reminder for laboratory personnel, custodians, and maintenance personnel to exercise caution and responsible action. The Authorized User ensures that labels on equipment, benches, and containers are appropriate. The RSO evaluates posting and labeling when auditing laboratory practices.

2.17.1 POSTING AT RADIATION USE AREAS

a.) Radioactive Materials. A warning sign bearing the radiation symbol and "Caution Radioactive Material" must be conspicuously posted in or at the entryways to labs and store rooms in which radioactive materials in amounts exceeding values on the Radionuclide Information form (*Required Area Posting*) are being used or stored [OAC 3701:1-38-18]. The name of the individual responsible for the posted area should be displayed at each entryway to facilitate contact in case of emergency. Warning signs must not be removed from any room, except by Radiation Safety personnel following a clearance survey.

b) Radiation Area. A warning sign bearing the radiation symbol and "Caution Radiation Area" must be conspicuously posted in or at the entryways to labs and storerooms in which a radiation area is present. A radiation area is an accessible area where the dose rate at 30-cm from the source or shielding exceeds 5 mrem/hr.

c) Notice to Employees. Ohio Department of Health form 4786.32, "*Notice to Employees*", must be visibly posted in or near laboratories where the radioactive materials are located [OAC 3701:1-38-10]. Each notice has been amended to include a statement indicating that users may review ODH rules, current licensing documents, or applicable operating procedures by contacting the Radiation Safety Officer.

d) Damaged Signs. The Authorized User will notify the RSO for replacement if any posted form is found to be defaced, altered, or removed.

e) Sign Removal. Only a representative of the Radiation Safety Office, following a release survey, may remove a posted radiation sign.

2.17.2 USE AREAS WITHIN LABORATORIES AND EQUIPMENT LABELS

a) Use Areas. The borders of use areas (e.g., benches, hot sinks, fume hoods) within the lab shall be conspicuously marked with "Caution-Radioactive Material" labels. Areas with residual contamination must also be marked and covered to prevent the spread of contamination. Laboratory personnel must survey for contamination when a use area is discontinued or moved to another location within a restricted laboratory. The survey documentation must be retained for 3 years.

b) Radiation Areas. Radiation areas in the laboratory, i.e., areas where radiation levels are sufficient to expose a continuously present individual to 5 millirem in any hour shall be labeled as a radiation area.

c) Equipment. Equipment or appliances (e.g., refrigerators, centrifuges, pipettes) used with or contaminated with radioactive material shall bear a label with the radiation symbol and "Caution-Radioactive Material". Labeled equipment must be surveyed for contamination prior to disposal, repair, or unrestricted use. The Radiation Safety Office will perform this survey when requested by laboratory personnel.

2.17.3 CONTAINER LABELS

a) Containers in which materials are held shall bear a durable, clearly visible label bearing the radiation caution symbol and the words "Caution Radioactive Material." The container label shall also indicate sufficient information, such as the following, so that persons working in the area can take precautions to minimize exposures. The information should include: isotope, compound, activity, radiation levels, and date of assay or receipt.

b) Removing Container Labels. Containers must be surveyed prior to release. All radioactive material markings must be removed or defaced from *uncontaminated, empty* containers before disposal or release for unrestricted use.

c) Exemptions to Containers Labeling.
   (1) Containers holding material in amounts less than indicated on the Radionuclide Information form, *Container Labeling*.
   (2) Containers attended by an individual who takes precautions to prevent exposure to others (e.g., beakers, flasks, and test tubes that are used transiently in laboratory procedures and subsequently cleaned in a hot sink).

2.17.4 SIGN / LABEL ACQUISITION

Radiation warning signs are available from the Radiation Safety Office. Labeling tape may be obtained from Laboratory Stores or commercial vendors.

2.18 SURVEYS FOR CONTAMINATION

Surveys for radioactive contamination are necessary to demonstrate either that no contamination is present or to identify contaminated surfaces so that they may be cleaned

before contamination spreads. Users shall perform sufficient surveys to identify any contamination resulting from their usage. The Radionuclide Information form shows recommended methods of laboratory monitoring for commonly used isotopes. Two methods of contamination monitoring are surveying for removable contamination (also called swipes or wipes) and using an operational survey meter for monitoring accessible surfaces.

2.18.1 SURVEYS FOR REMOVABLE CONTAMINATION (SWIPES)

a) Swipe Frequency. Use and adjacent work areas must be surveyed for removable contamination:

(1) **Monthly**, if the activity used in a day is **200 μCi or less**. The Radiation Safety Office routinely performs these surveys.

(2) **Weekly**, if the activity used in a day is **more than 200 μCi**. These surveys must be performed within one week after the high usage. The user is responsible for ensuring these surveys are completed. The Radiation Safety Office will perform this survey on request.

(3) **By the end of the day**, if **1 mCi or more** of ^{125}I is used (see Iodinations). When using more than 1 mCi of other beta or gamma emitters, users are encouraged to perform swipe surveys immediately following usage. The Radiation Safety Office will perform these surveys on request. After use of ^{32}P (or other high energy beta or gamma unsealed sources), a complete survey of the user and the work area with an operational survey meter must be performed.

(4) **Immediately**, if contamination is suspected.

b) Recommended Swipe Procedures.

(1) Put on a plastic glove on the swiping hand. This requirement may be waived in non-use areas where contamination is not expected.

(2) Use a wet or dry swipe pad (filter paper is acceptable). Wet pads collect contamination more efficiently, but are harder to work with than dry pads.

(3) Applying moderate pressure, press the pad on the surface to be monitored. The area surveyed should cover 100 cm^2 ($\approx$ 4" x 4"). If no contamination is expected, the survey area can be expanded.

(4a) *Liquid Scintillation Counting (for α, β, and low-energy γ emitters)*.
Place the swipe pads in individual scintillation vials and add scintillation cocktail. In one vial add a blank pad, which represents the background level. Count the vials using a program that includes the energy of the isotope used.

(4b) *Gamma Well Counting (for γ emitters only)*
Place the swipe pads in individual counting tubes. In one tube add a blank pad, which represents the background level. In another tube, add a reference source (e.g., ^{125}I-Sim, ^{137}Cs - depending on the energy of the suspected contaminant). Count the tubes using a program that includes the energy of the reference source and the isotope used.

c) Swipe Result Documentation. The print out from the counter may be used as documentation for the survey or the survey data may be transcribed to another sheet. The record must contain the following information and be **retained for 3 years** for review by inspecting personnel. A diagram of the lab is helpful to correlate the survey results to physical locations in the lab. The record should include the:

(1) date
(2) room number,
(3) make and model of the instrument used to count the swipes,
(4) cpm (and dpm, if the efficiency or quench curve is established),
(5) a means of tracking the swipe results to specific locations in the lab (i.e., descriptively (e.g., floor near fume hood) or diagrammatically (e.g., correlate the value to a diagram of the lab)), and
(6) signature or initials of the person performing the survey.

d) Swipe Action Levels.

(1) *Restricted Areas.* Work areas and equipment should be kept as free of contamination as practical. The action level for decontamination of β or γ emitters is **200 dpm per 100 cm²** or **three times background**. The action level for decontamination of α emitters is 20 dpm per 100 cm².

(2) *Unrestricted Areas*. In unrestricted areas or areas that are to be released for unrestricted use, no contamination should be evident. This condition is met if the measured values cannot be distinguished from background level (i.e., are less than the minimum detectable level (MDL) for the detecting system). The following equation may be used for determining the MDL, where R_b is the background count rate (cpm) and t_s is the sample counting time (minutes, providing the counting times for the background and sample are the same).

$$MDL = \frac{3 + 3.29\sqrt{2 R_b t_s}}{t_s}$$

An acceptable level exists when the sample count rate minus the background count rate is less than the MDL. Values that exceed the MDL will be evaluated on a case-by-case basis by the RSO.

2.18.2 SURVEY METER MONITORING

Laboratories that use over 200 μCi of high-energy β or γ emitters must be equipped with a portable survey meter for personnel and area monitoring. Gloves and the use area should be monitored frequently during operations using radioactivity. After the procedure is completed, the user should monitor all potentially contaminated surfaces (e.g., the use area, gloves, lab coat, shoes, adjacent areas). This survey is required when using 1 mCi or more of high-energy beta or gamma emitters. If the survey is negative, the gloves should be disposed and hands washed prior to leaving the laboratory.

a) Meter Appropriation. Investigators involved in research are encouraged to acquire their own instruments for routine use from the funding for their research. The

Radiation Safety Office will provide consultation on the selection of instruments for purchase. For special applications, survey meters may be loaned from the Radiation Safety Office.

b) Calibration / Repair. The Radiation Safety Office provides annual calibration for most survey meters. The cost of repair or replacement of instruments damaged through misuse or careless handling is the responsibility of the laboratory.

c) Operational Checks. Prior to use, the survey meter should be checked to ensure it is operating properly. Never use a survey meter that is not fully operational. Check the:
   (1) *Battery condition*. If low, change the batteries or consult the RSO.
   (2) *Calibration label*. The instrument should be calibrated within 1 year.
   (3) *Meter response* with a check source on the side or stock vial.

d) Monitoring Procedures. Use the open window part of the probe for maximum detectability. Move the detector slowly about ¼ inch from the surface. Using the audio (if available) facilitates detection at background levels. Sporadic counts may be due to cable movement. Areas where this occurs should be monitored again with the detector movement suspended until the reading can be made. Questionable areas should be cleaned or swiped. Most meters read in either “mR/hr” or "cpm" or both.

e) Survey Action Levels. Any unlabeled area that clearly reads above background should be cleaned and resurveyed. Decontamination must be initiated if measured levels exceed 100 cpm or 0.1 mR/hr above background. If the contamination cannot be removed, notify the Authorized User and the RSO. Also, the Authorized User and RSO must be notified of any personal contamination.

2.18.3 RELEASING EQUIPMENT FOR REPAIR OR UNRESTRICTED USE

Labeled or potentially contaminated equipment may not be removed from a restricted area to an unrestricted area for any purpose (including repair, maintenance, disposal, or resale) until it is determined to be free of contamination by Radiation Safety personnel, who will document the release in writing. A copy of the release documentation should accompany the equipment to its destination. All radiation-warning labels must be removed from the equipment before it leaves the restricted area.

If the survey reveals evidence of contamination, the equipment will not be released until it has been decontaminated. Authorized Users are responsible for cleaning their equipment. The Radiation Safety Office will assist decontamination efforts upon request. Notify the RSO if contamination cannot be removed. If repair of contaminated equipment is necessary, Radiation Safety personnel or an approved user will monitor the work to ensure that necessary precautions are observed.

2.18.4 RELEASING LABORATORIES FOR UNRESTRICTED USE

Any restricted laboratory or storage room requires a survey for contamination prior to releasing the area for unrestricted use. Radiation Safety personnel will survey all areas and equipment marked with "Radioactive Material" warning labels. The survey will randomly include other

areas (counters, floors, equipment, desks, sink basins, and traps) for assurance. Potential storage areas (e.g., cabinets, drawers, refrigerators, and freezers) will be visually inspected for any item bearing a radiation-warning label. Once the lab is found to be free of radioactivity and contamination, all warning signs are removed and the Authorized User (or Department Chair if the Authorized User has left the university) is informed of the results in writing.

2.19 RADIOACTIVE SPILLS / EMERGENCY RESPONSE

2.19.1 RESPONSE TO MINOR SPILLS OF LIQUIDS AND SOLIDS (< 1 mCi)

a) Warn people in the area that a spill has occurred. Restrict uninvolved people from entering the area.
b) Prevent the spread of contamination by covering the spill with absorbent paper. Establish a boundary to the spill site. [**Note:** If the material evaporates quickly (e.g., a toluene solvent), turn on a nearby fume hood and vacate the area. Notify the RSO as soon as possible.]
c) Wearing protective clothing (gloves, lab coat, eye protection, and shoe covers), clean up the spill with absorbent paper, soap and water, or a commercial decontamination agent. Place contaminated materials in radioactive trash.
d) Survey the area. Check the hands, clothing, and shoes of potentially contaminated persons for contamination.
e) Report the spill to the Authorized User and RSO (Emergency Contact Phone Numbers). The RSO will complete the Radioactive Spill Report.
f) Continue decontamination as needed.
g) Place all contaminated materials into properly labeled radioactive waste containers.

2.19.2 RESPONSE TO MAJOR SPILLS OF LIQUIDS AND SOLIDS (> 1 mCi)

a) Clear the area. Inform all persons not involved in the spill to leave the room.
b) Prevent the spread of contamination by covering the spill with absorbent paper, but do not clean it up. Prevent the spread of contamination by limiting the movement of persons who may be contaminated.
c) Close the room and lock (or otherwise secure) the area to prevent entry.
d) Immediately, notify the RSO and Authorized User. The RSO will supervise the clean up and complete the Radioactive Spill Report.
e) Remove contaminated clothing and decontaminate affected persons.

2.19.3 FACILITY DECONTAMINATION

Users, under the direction of the Authorized User, are generally responsible for decontaminating laboratory equipment or spaces. The level of contamination should be assessed and preparations for decontamination should begin as soon as possible. Soap and water or commercial decontamination agents are able to reduce the contamination to acceptable levels in most cases. Should the contamination persist or the activity spilled be 1000s of dpm, obtain assistance from the Radiation Safety Office.

2.19.4 PERSONNEL DECONTAMINATION

a) Skin Decontamination. If contamination is found on the skin, **immediately** wash the contaminated area of the body for 2 to 3 minutes in warm water with a mild soap or a commercial cleaning agent *specifically designed for skin decontamination*. Avoid prolonged or coarse scrubbing that irritates the skin, which can increase absorption and inhibit further decontamination efforts. Notify the Authorized User and RSO immediately after the decontamination effort. The RSO may attempt more advanced decontamination techniques or perform a bioassay, if indicated.

b) Wound Decontamination. If an incident occurs where the skin is broken and contamination is evident, contamination of the wound should be suspected. Immediately notify the Authorized User and the RSO. Cover the wound with gauze or a bandage, and cleanse the adjacent skin with soap and tepid water. Uncover the wound and wash the injured site with soap and tepid water. Monitor the wound and skin for residual contamination. If medical care is needed, see Medical Emergencies.

c) Internal Decontamination. Immediately notify the RSO if internal contamination is suspected. Body surveys and bioassays (e.g., urine or fecal sampling) may be necessary. The treatment for internal contamination depends on the radioisotope and its chemical nature. Some dose reduction methods may involve administration of agents that reduce absorption, a large intake of fluids, or induction of vomiting. If medical care is needed, see Medical Emergencies.

d) Clothing Decontamination. Contaminated clothing must be removed as soon as a temporary change of clothes is available. The Radiation Safety Office will take possession of contaminated clothes and will return them to the owner either after decay or successful decontamination and monitoring. **Do not** use the university laundering facility for washing contaminated clothes or lab coats.

e) Report of Contamination. A report of contamination will be completed by the Radiation Safety Office, with input from involved parties, and forwarded to the Radiation Safety Committee for review. The report will include the circumstances leading to the incident, the chemical form, activity and method of assay of the radionuclide, how the accident occurred, and subsequent actions.

2.19.5 MEDICAL EMERGENCIES

Situations involving personal injuries may vary significantly. The outcome of an emergency depends largely on the discretion of those persons present. The following list of priorities prescribes general guidance for emergency actions. Don't Panic. The university procedures for injuries and illnesses are outlined in *Wright Way Policy 6031*. *Inform health care providers when contamination may be present so that they may utilize proper protective measures.*

a) **Remove the injured persons from imminent hazards (e.g., fire) and render first aid to save the victim's life or stabilize the injury.** A person without life-threatening injuries, such as a broken arm, may be decontaminated before seeking medical assistance. Call the RSO immediately.

b) **Report the injury (and hazardous condition, if one exists) to the Public Safety Communications Center** (dial 911 or ext. 2111 or use an emergency telephone located in the corridors throughout campus). For off-campus laboratories, use medical facilities immediately available (e.g., Kettering Hospital or the VA Medical Center). If these facilities are not immediately available, call the local paramedics for assistance. The injured party should always be accompanied by a university employee whenever possible. Do NOT delay treatment for radioactive decontamination, unless the injury is not critical.

c) **Notify the RSO and Authorized User** (Emergency Telephone Numbers). Brief the Radiation Safety Officer, upon his arrival, on the events that occurred, personnel involved and injured, and their disposition.

d) **Protect yourself from contamination** by wearing protective covering (e.g., gloves, boots, and lab coat).

e) Take steps to **prevent or minimize the spread of contamination** and make the patient comfortable. Restrict the entry of unnecessary persons into potentially contaminated areas. Detain potentially contaminated persons in a safe location.

f) **Do not attempt to fight a fire** unless it can be easily controlled and you are trained in the use of fire extinguishers. Avoid inhalation of smoke, fumes, and dust.

2.20 BIOASSAYS FOR INTERNAL EXPOSURE

Bioassays for measuring internal radiation exposure are performed whenever an intake of radioactive material is suspected, when a user may exceed 10% of the Annual Limit on Intake (ALI), a minor or declared pregnant woman may intake a committed effective dose of 50 mrem (0.5 mGy), or at the discretion of the Radiation Safety Officer.

a) Thyroid Bioassay. Approximately 30% of radioiodine taken in the body deposits in the thyroid gland. Thyroid bioassays are required before the first iodination procedure and after each procedure thereafter. This exam monitors the thyroid gland using a sodium iodide (NaI) detector. Post-iodination bioassays are performed between 24 and 72 hours after the procedure. An immediate bioassay should be performed if an intake of iodine is suspected, so that a thyroid-blocking agent can be administered, if necessary. *Any person who refuses to have a thyroid bioassay performed will not be allowed to take part in an iodination procedure.*

b) Bodily Waste Analysis. After an intake of radioactive materials has occurred, some of the unabsorbed materials are eliminated as waste and can be measured in the person's urine or feces, depending on the radioisotope. A urine sample is a relatively simple procedure that can determine intake. Any refusal to submit a sample for analysis must be documented.

c) Nasal and Throat Swabs. Swabs of the nasal opening and throat can indicate that an acute inhalation exposure has occurred. These samples may be taken by the RSO following a suspected inhalation incident. Any refusal to submit to this procedure must be documented.

2.21 IODINATION PROCEDURES

2.21.1 RADIOIMMUNOASSAY (RIA) KITS

Radioimmunoassay (RIA) kits have compounds labeled with ^{125}I and activities less than 10 μCi. A fume hood, survey meters, and bioassays are not usually required for using RIA materials. When using materials in any form labeled with radioactive iodine in amounts greater than 10 μCi, additional protective measures may be warranted.

2.21.2 IODINATION PROCEDURES

An iodination process uses an unlabeled radioiodine to label a compound. This process typically utilizes millicurie quantities of ^{125}I and poses a genuine potential for exceeding the university release limits, contaminating laboratory personnel and spaces, or incurring an intake of radioactivity. For these reasons, the following requirements for iodinations apply:

a) Inform the RSO at least 2 days in advance of each iodination procedure.

b) A thyroid bioassay must be performed on each participant *before* the first iodination. *After each* iodination thereafter, a follow-up thyroid bioassay must be performed between 24 and 72 hours of completion.

c) Inform the RSO *immediately* if inhalation or personal contamination is suspected. If an intake is confirmed a potassium iodide blocking agent must be administered as soon as possible to mitigate exposure to the thyroid. The recommended KI dose is 1.4 mg/kg body mass [ref: Ribela, M.I., Health Physics, 76 (1): 11-16, 1999]. KI when given within 4 hours of exposure provides about 68% blocking effectiveness.

d) Prepare an "iodine trap" solution of 0.1 M each of sodium thiosulfate, sodium iodide, and sodium hydroxide if the iodination procedure is performed outside of the iodination glove box. This solution will trap free iodine for decontamination and disposal purposes.

e) The work must be performed in a fume hood, vented to the outside, with a minimal flow rate of 100 ft/min. The flow rate must have been certified within the past 12 months. Ensure the fan is on during the procedure. Keep the sash at a low, but comfortable position to maximize negative draw.

f) An iodination glove box with charcoal absorbers must be used to mitigate the release of ^{125}I to the atmosphere. Ensure the fan works properly during the entire procedure.

g) A calibrated survey meter with a low-energy gamma detector is required. Frequent monitoring of gloves and around the fume hood should be performed to quickly identify contamination.

h) First practice the iodination procedures without radioactivity to become familiar with the steps involved and identify ways to reduce the potential of exposure.

i) Wear two pair of gloves to prevent absorption through the skin. Change the outer pair immediately if contaminated.

j) The RSO may monitor the vented exhaust from the fume hood and the breathing zone of the person performing the iodination to ensure no limits are exceeded.

k) Keep contaminated trash in the fume hood as long as possible. Double bag the waste for pick-up by EHS.

l) Monitor gloves, exposed clothing, lab coat, and the work area (including the floor) for contamination after completion of work. Monitor and wash hands before leaving the lab.

m) Survey the use area for removable contamination following the iodination procedure.

n) Notify the RSO if personal or laboratory contamination is suspected.

2.22 SEALED RADIOACTIVE SOURCES

2.22.1 LEAK TESTS OF SEALED SOURCES

Sealed sources must be leak tested by the Radiation Safety Office upon receipt and every six months. The method of testing must be able to detect the presence of 0.005 μCi, which is the ODH action level. Should this level be met or exceeded, the source will be removed from service for decontamination, repair, or disposal. The event must be reported to the ODH within 5 days. The radioactive material license lists the categories of sources that are exempted from the leak testing requirement.

When a non-exempt sealed source is removed from storage, it shall be leak tested before use or transfer. Stored sealed sources shall be leak tested at least every 5 years.

2.22.2 GAS CHROMATOGRAPHY EQUIPMENT

Electron capture detectors (ECDs) available on some gas chromatography units contain radioactive foils used to ionize the carrier gas. The foil, which contains 15 mCi or less of ^{63}Ni, is contained in a detector cell. The carrier gas enters the bottom of the cell, passes by the radioactive foil, and exhausts at the top. The exhaust must be vented to the outside. An effluent trap may be used to capture exhaust vapors, if approved by the Radiation Safety Officer.

The radioactive source shall not be removed from the ECD. In order to ensure the integrity of the detector foil, adhere to the manufacturer's guidelines for use. The detector can only be cleaned under the direction of the Authorized User using procedures established by the manufacturer. Inform the RSO each time that this procedure will be performed so that the source may be leak tested after the cleaning process.

If damage to the detector is suspected, immediately notify the Authorized User and the Radiation Safety Officer. A test for source leakage and radioactive contamination should be performed before removing a potentially damaged source. A contaminated ECD must be handled with caution to prevent the spread of contamination. After the detector has cooled, remove it with gloved hands. Wrap the gloves around the ECD after removal to contain any contaminants.

2.23 ANIMAL USAGE INVOLVING RADIOACTIVE MATERIALS

If facilities of the Laboratory Animal Resources (LAR) department are to be used for housing, care, or feeding of animals contaminated with radioactive material, Form LAR/RSO 14, "Animal Care Information", must be completed and signed. It is submitted with the protocol application, Form RSO3, to the University Radiation Safety Committee and Director of Laboratory Animal Resources for approval. If care and maintenance by LAR caretakers is not needed after animals are injected with radioactive materials, Form LAR/RSO 14 is not required; however handling and disposal should be clearly addressed on the protocol application, Form RSO 3. Experimental animals shall not be used for human consumption.

The Authorized User must ensure that the presence of radioactivity and specific instructions are fully communicated to lab animal staff by ensuring the following requirements are met.

a) Posting. The entryway to a room holding contaminated animals shall be posted with a "Caution: Radioactive Materials" sign.

b) Instructions. Instructions for caretakers must be posted on or near the animal cages. A Lab Animal Information Notice fulfills this requirement when completed and signed. The instructions should address relevant information regarding personal protection, dosimetry, feeding, changing bedding, disposition of dead or ill animals, and any special directions required for experimental control.

c) Labeling. Cages housing contaminated animals, waste containers, and any potential contaminated equipment must be properly labeled with "Caution: Radioactive Material" tape. The labels on cages and waste should indicate the isotope, date (or beginning date) of administration, estimated activity of radioactive material, and the Authorized User.

d) Containment. Radioactive animal waste must be contained by using under pads, collecting urine, or other means, as appropriate.

e) Survey/Decontamination/Cleaning. The warning labels on potentially contaminated cages should be removed just before being washed. The Radiation Safety Office will survey potentially contaminated equipment upon request.

f) Transport. Movement of contaminated animals through uncontrolled areas of the University is discouraged. If necessary, Form RSO 3 will specify precautions to be taken to prevent contamination of uncontrolled areas and unnecessary exposure of anyone in these areas.

2.24 RADIOACTIVE WASTE

Safe disposition of radioactive waste materials comprises an essential component of the Radiation Safety Program and regulatory compliance. The Authorized User is responsible for ensuring that radioactive waste is properly contained, labeled, and disposed. Each proposed use protocol should address the types of radioactive waste expected to be generated and the disposal methods. Contact the Radiation Safety Office (775-2169) if you have any questions regarding disposal of any specific waste.

2.24.1 CONTAINMENT AND LABELING OF WASTE

Radioactive waste bears the same precautions as the radioactive materials. The materials must be properly contained to prevent spills or breakage. The type of container is specific to the type of material. Correct labeling of the waste container is essential to ensure that the contents are identified and that the material is not mistakenly discarded as regular trash. Materials that comprise of high-energy β or γ emitters should be shielded to reduce exposure to laboratory personnel.

2.24.2 DISPOSAL RECORDS

Documentation of waste disposal is mandatory for regulatory compliance. Waste disposal records must be retained indefinitely. Authorized Users must ensure that the distribution of disposed radioactive waste is accurately communicated to the Radiation Safety Office. The most effective means of accomplishing this is recording distribution information on the Inventory Card. The Inventory Card is returned to the Radiation Safety Office when the radioactive material is expended.

a) Documentation on the Inventory Card. As radioactive waste is disposed, the means of disposal should be summarized on the *Inventory of Radionuclides* (Yellow) Card (Form RSO 10). The summary should identify the waste method (e.g., drain or sink, solid, liquid, organic scintillation, mixed waste) and estimated activity or percentage of activity for each disposal route.
b) Labeling. All waste containers submitted to the Radiation Safety Office for disposal must be tagged with a label appropriate for the waste contents. When properly completed, these labels provide the information needed for proper disposition. Labels for solid, liquid, scintillation vial, and animal wastes are available from the Radiation Safety Office. For waste contaminated with short half-life material (<120 days) and with consideration for ALARA, remove or deface radiation labels before discarding the waste into radioactive trash. This will help the Radiation Safety Office with the disposal process.

2.24.3 WASTE MINIMIZATION

The high cost of radioactive waste disposal and the spirit of efficient utilization of resources require practical and cautious means of reducing waste volume, primarily by minimizing waste generation. Some methods are:

a) substituting non-radioactive compounds or radioisotopes with half-lives less than 120 days where practicable.
b) carefully segregating radioactive waste from non-radioactive waste.
c) separating short-lived radioactive waste (i.e., half-life less than 90 days) from long-lived radioactive waste (i.e., half-life greater than 120 days).
d) avoiding unnecessary contamination of items during the use of radioactive materials.
e) purchasing the minimum amount of radioactivity needed for experimental purpose.
f) decontaminating materials.
g) avoiding generation of mixed waste.

2.24.4 SOLID WASTE

a) Unbreakable Waste. Solid, non-reusable, unbreakable waste, such as contaminated absorbent paper, gloves, empty containers, must be placed in a heavy-duty plastic bag. Consider double bagging waste that contains millicurie levels of radioactivity or where a single bag may not adequately hold the contents. **IMPORTANT:** Do *NOT* place sharp objects such as syringe needles or razor blades in waste bags. Doing so could result in injury and contamination of personnel. Always discard needles in a properly labeled sharps container that is not used for chemical or biological waste purposes.

b) Breakable Waste. Solid, breakable, non-reusable waste, such as contaminated glass pipettes and beakers must be placed in an appropriate container, such as a cardboard box lined with a plastic bag. The added support will prevent personal injury or internal contamination should the material break.

c) Pick-up. When the container is sealed and properly labeled, call or e-mail the Radiation Safety Office (775-2623/2169) to remove the waste.

d) Disposal. The Radiation Safety Office will dispose of the material according to its half-life. Materials with a half-life less than 120 days are held for decay-in-storage and materials with half-lives greater than 120 days are disposed as low-level radioactive waste.

2.24.5 LIQUID WASTE

The disposal method for liquid radioactive waste depends on its solubility in water and its EPA hazard class. Liquid waste intended for pick-up by Radiation Safety Office personnel must be placed in a sealed, non-leaking container (e.g., capped plastic or glass bottle) and tagged with a properly completed Liquid Waste label available from the Radiation Safety Office.

a) Liquid Waste Soluble in Water. Liquid radioactive waste that is soluble in water may be disposed into the sewer system providing the following conditions are met. Short-lived material (i.e., half-life less than 120 days) can be held for decay to minimize the activity released.
   (1) The liquid must be readily soluble in water. Compounds described in the Handbook of Chemistry and Physics as Very Soluble (VS) or Soluble (S) fulfill this requirement. NOTE: Readily dispersible biological material is also allowable with approval from the Radiation Safety Officer.
   (2) The sink used must be designated as a "Hot Sink" and labeled as such.
   (3) The liquid must not be a hazardous waste that would violate disposal regulations of the EPA. Contact the Hazardous Waste Manager (775-3118/2215) if the waste may fall into this category.
   (4) Monthly disposal limit per lab. Contact the RSO if you may exceed these values:
   Tritium (^{3}H): 1000 μCi (1 mCi, 37 MBq)
   Carbon-14 (^{14}C): 500 μCi (0.5 mCi, 18.5 MBq)
   All other radionuclides combined: 500 μCi (0.5 mCi, 18.5 MBq)

b) Liquid Waste **NOT** Soluble in Water. Liquid radioactive waste that is *NOT* soluble in water must be picked up by the Radiation Safety Office for disposal.

2.24.6 LIQUID SCINTILLATION VIALS

The disposal method for liquid scintillation vials depends on the type of scintillation fluid and the concentration of activity. Scintillation vials must be securely capped to prevent leakage. Vials disposed through the Radiation Safety Office should be in a vial tray (or otherwise stored upright in a box) that is properly labeled.

a) Biodegradable Liquid Scintillation Fluid. Before disposing of a scintillation fluid marketed as biodegradable down a sink as liquid waste, verify the material is suitable for sewer disposal by contacting the RSO or Hazardous Waste Manager (775-2169/3788). Once clearance is obtained, sink disposal is acceptable providing no solids or insoluble materials are released into the sink. The empty vials should be rinsed out two or more times before disposal in regular trash.

b) Organic Liquid Scintillation Fluid. Organic or non-biodegradable scintillation fluid must be picked up by the Radiation Safety Office for disposal.

c) Exempted Levels of Activity. Liquid scintillation vials containing ^{3}H or ^{14}C with activities less than 0.05 μCi per gram of scintillation fluid may be disposed as if they were not radioactive. Any vials that are to be picked-up by the Radiation Safety Office must be properly labeled regardless of exempted status.

2.24.7 DECAY-IN-STORAGE

a) The university may hold materials with half-lives of less than 120 days for decay-in-storage. The material must be held for 10 half-lives. A survey must be performed to verify that the material cannot be discerned from background. All radiation labels must be removed or obliterated prior to disposal as normal trash.

b) Records of Disposal. A record of each disposal must be held for at least 3 years. The record must include the:
   (1) disposal date,
   (2) radionuclides disposed,
   (3) survey instrument used,
   (4) background dose rate,
   (5) dose rate measured at the surface of each container, and
   (6) name of the person who performed the disposal.

2.24.8 ANIMAL WASTE

a) Containment. Animal carcasses, excrement, and associated wastes containing radioactivity will be wrapped in absorbent paper, placed in a plastic bag, and refrigerated or frozen. Double bagging and packaging in a box or can is encouraged when one bag may not hold the waste. Contact the Radiation Safety Office for disposal.

b) Labeling. The container of contaminated animal matter must be tagged with an Animal Waste label available from the Radiation Safety Office.

c) Exempted Levels of Activity. Animal waste containing ^{3}H or ^{14}C with activities less than 0.05 μCi per gram of animal tissue averaged over the entire animal may be disposed as if the material were not radioactive. Waste meeting these criteria should be addressed in the user's protocol or in supplementary documentation.

2.24.9 MIXED WASTE

Mixed waste is radioactive waste that also contains other hazardous materials regulated by the EPA. These materials must be segregated from other waste streams in suitable containers bearing Liquid Waste labels. On the label list the contents and percent composition. Acids should be neutralized, unless the neutralization process may release radioactive gases. Volatile materials that are flammable, explosive, or sublimate require extra caution. Any extra care required in handling should be indicated on the container.

2.24.10 INFECTIOUS WASTE

Radioactive, infectious agents should be inactivated or neutralized prior to release for disposal as radioactive waste. The protocol for usage should address the proposed process for neutralization and disposal.

2.24.11 INCINERATION

Incineration of radioactive waste is **NOT** permitted. The following waste can be incinerated:
a) animal carcasses containing exempted levels of radioactivity and
b) materials released by decay-in-storage may be incinerated in lieu of removing radioactive labels.

III. RADIATION-PRODUCING DEVICES

3.0 INTRODUCTION

The policies and procedures of the Radiation Safety Manual apply to the use of radiation-producing devices (RPDs) governed by Chapters 3701:1-38 and 3701:1-66 of the Ohio Administrative Code (OAC). All RPDs, whether active or in storage, must be registered with Ohio Bureau of Radiation Protection (OBRP).

RPDs (also known as radiation generating equipment) consist of a wide variety of devices such as diagnostic, veterinary, and analytical x-ray units, as well as particle accelerators, that are used for specific purposes in research and/or patient care. These facilities differ broadly in their potential for harm. This manual provides general guidance for safety and usage. Required operating procedures for each facility give more detailed information and procedures relevant to safety and regulatory compliance. The provisions of the Radiation Safety Manual and the operating procedures for each device constitute the Quality Assurance Program required by OAC 3701:1-66-04.

3.1 FACILITY COORDINATOR

A Facility Coordinator (FC) shall be named for each facility utilizing RPDs. The Facility Coordinator administratively oversees and coordinates RPD operations and maintenance to ensure appropriate and safe usage. Additionally, the FC serves as a conduit for communications between the RSO (and the Radiation Safety Committee) and the Faculty Users in matters concerning the RPD facility operations and safety.

3.1.1 FACILITY COORDINATOR QUALIFICATIONS

The Chair of the department housing the RPD facility nominates the prospective Facility Coordinator for approval by the University Radiation Safety Committee. The Facility Coordinator should be a Faculty User or an individual who has sufficient knowledge, experience, and administrative authority to reasonably assure safety, oversight, and control of the RPD(s).

3.1.2 FACILITY COORDINATOR RESPONSIBILITIES

a) Produce operating procedures for the facility that include appropriate requirements from OAC 3701:1-66. The Radiation Safety Manual and Operating Procedures must be accessible to RPD operators at all times.

b) Review the operating procedures periodically to ensure they are current.

c) Establish and administer controls limiting access to each device to approved operators, and scheduling its use.

d) Develop training programs for operators and any individual likely to receive a radiation dose of 100 mrem or more per year from the facility.

e) Arrange for appropriate maintenance of each device and schedule housekeeping services for the facility. A record of maintenance is required.

f) Ensure that regular tests are made to verify the functioning of safety features as specified in the operating procedures.

g) Arrange with the RSO for periodic surveys of the safety features of each device, and keep the RSO informed of any changes that would affect the radiation output or safety aspects of any device.

h) Inform the RSO of acquisition of new equipment or removal from service of old equipment to ensure that registrations with the OBRP are kept current.

i) Immediately inform the RSO and Department Chair of any situation resulting in or that could have resulted in personal injury.

j) Inform the RSO and Faculty Users of any significant modifications to existing equipment, facility alterations, or construction near the facility that may affect personnel safety or the adequacy of shielding.

k) Communicate to Faculty Users any change in operating status of the device or required operating procedures.

3.2 FACULTY USER

A Faculty User (FU) is a departmentally affiliated member of Wright State University, authorized by the Radiation Safety Committee to use specific RPDs independently and supervise subordinate operators. Operation of RPDs must fully comply with research protocols approved by the committee. The FU is responsible for the safe use of the device, including operation by anyone under his/her direction and protection of other personnel. Additionally, the FU shall ensure that subordinate operators are familiar with Operating Procedures, have proper training to safely perform each assigned task, and can respond appropriately to emergency situations. Research protocols must be submitted for RSC approval before use of the RPD. A Faculty User using x-rays for clinical (human exposure) purposes must either be a physician or have approval from WSU's Institutional Review Board.

FACULTY USER QUALIFICATIONS

A prospective Faculty User must apply to the Radiation Safety Committee for approval. The applicant shall submit his/her training and experience on Form RSO2. The FU must:

a) possess at least a bachelors degree in a relevant field;
b) have 40 hours of training and experience operating similar RPDs;
c) possess a Radiation Safety Manual;
d) review the manual, facility operating procedures and applicable OBRP rules with the RSO, while paying close attention to FU responsibilities, operator training, and other issues related to RPD usage and safety;
e) ensure the training requirements for facility operator are fulfilled.

The FU's experience with RPDs should be reasonably current. The Radiation Safety Committee will judge the adequacy and currentness of experience on a case-by-case basis.

An applicant who is otherwise qualified may gain experience using an RPD as an operator under the supervision of an approved Faculty User. Upon written recommendation by the supervising Facility Coordinator, the committee may upgrade the applicant's status to Faculty User.

A Faculty User's protocols to use an RPD are not transferable to another FU, unless approved by the RSC. For instance, the research of a FU planning to go on sabbatical cannot be continued unless the research is accepted by another FU approved by the committee for a similar protocol.

3.2.2 FACULTY USER RESPONSIBILITIES

a) Ensure that operation, including that by subordinate operators, is compliant with the provisions of the facility operating procedures, approved protocols, and the Radiation Safety Manual.

b) Provide sufficient training and supervision to subordinate operators such that they operate the device safely. The training must be documented on a Laboratory Hazard Instruction form or a similar form designated in the Operating Procedures. Ensure bystanders or visitors who may receive 100 mrem or more per year have similar documented training.

c) Never allow operation of an RPD when unsafe conditions are evident. Do not operate an RPD or immediately cease operations if a malfunction occurs that may affect safety (e.g., burnt out warning light, interlock failure, water near high voltage sources). Refrain from operations until the problem or malfunction is corrected. Take positive steps (e.g., post a "DO NOT USE" sign, "lock out/tag out" the unit) to ensure the unit is not used prior to repair. Immediately inform the Facility Coordinator.

d) Keep the Radiation Safety Manual and Operating Procedures accessible to operators. Ensure operators under the FU's direction are familiar with the emergency procedures for the RPD.

e) Submit protocols to the RSC for research projects using the RPD and perform only projects that fall under the umbrella of an approved protocol.

f) Keep protocols current as procedures and operators change. Send updated information to the RSO by memorandum. Review all current protocols for accuracy and any change that may affect radiation safety at least biennially (every two years).

g) Ensure all operators have appropriate dosimetry devices (e.g., OSLDs, finger rings) and check regularly on their use.

h) Before operating an RPD, visually check and clear anyone in the exposure room who may be unnecessarily exposed to radiation.

i) Inform the RSO and Facility Coordinator immediately of any safety related incident that has or could have resulted in personal injury, even if it occurs after normal working hours.

j) Ensure that facility logbook entries, if required, are recorded for routine use and "notable" events; e.g., malfunctions and repairs, unusual operating conditions.

k) Ensure that the RPD is left with power "off" after use with equipment and door to facility secured against unauthorized use.

3.3 FACILITY (RPD) OPERATOR

A Facility Operator (FO) is a departmentally affiliated member of the university, who operates a radiation-producing device for research purposes, excluding live humans, under the direction of a Faculty User with a limited degree of independence. The FO is responsible for the safe performance of his/her own activities. The FO can assist the FU with training new operators in the lab. The Faculty User must apply to the Radiation Safety Committee to add a person to his/her protocol as a Facility Operator. The Radiation Safety Committee grants approval of FO status based on completion of the operator's training. The RSO may approve persons who are clearly qualified.

3.3.1 FACILITY OPERATOR TRAINING

The Faculty User must:

a) If applicable, submit the prospective operator's prior training and experience on Form RSO2 to the RSO.
b) Provide and document training to each new operator on the topics addressed in the Operating Procedures. The Laboratory Hazard Instruction form may be used if the operator will likely receive a total effective dose equivalent of 100 mrem per year.
c) Provide direct (observed) supervision for each operation until the Faculty User is confident that the prospective operator complies with the Operating Procedures and can work independently. The period of supervision depends on the perspective operator's performance and previous experience with similar devices.
d) When training is complete, add the individual to the Faculty User's authorization by submitting a memorandum to the RSO for approval/review by the RSC.

3.3.2 FACILITY OPERATOR RESPONSIBILITIES

a) Operate only RPDs for which approval has been granted.

b) Adhere to the safety rules and regulations as promulgated in this manual, facility Operating Procedures, and any communications from the RSC.

c) Wear issued radiation dosimeters when the RPD is operating. Return the dosimeters to the Radiation Safety Officer when use is discontinued.

d) Operate the RPD in such a way as to keep radiation exposures As Low As Reasonably Achievable *(ALARA)*.

e) Before operating an RPD, visually check and clear anyone from the exposure room who may be unnecessarily exposed to radiation.

f) Ensure that the RPD is left with power "off" after use with equipment and door to facility secured against unauthorized use.

g) Inform the RSO and the Faculty User immediately of any safety related incident that has or could have resulted in personal injury, even if it occurs after normal working hours.

h) Ensure that facility logbook entries, as applicable, are recorded for routine use and for "notable" events; e.g., malfunctions and repairs, unusual operating conditions.

i) Report any malfunctions or unusual operating conditions to the responsible Faculty User and the Facility Coordinator.

3.4 MEDICAL RPD OPERATORS

A Medical RPD Operator (MO) is a departmentally affiliated member of the university who uses a RPD under the direction of a Faculty User approved for clinical use. A MO must hold either a Radiographers or an X-ray Machine Operators license issued by ODH to operate a x-ray unit used to expose humans, excluding cadavers, to the primary beam. The MO is responsible for the safety of the patient, compliance with the facility operating procedures, and acting in a safe manner. The Faculty User must apply to the Radiation Safety Committee to add a person to his/her protocol as a medical RPD operator. Approval of MO status is granted by the RSC based on completion of licensure and fulfillment of training specified in the facility Operating Procedures. Subject to review by the RSC, the RSO may approve persons who are clearly qualified.

3.4.1 MEDICAL RPD OPERATOR TRAINING

The Faculty User must:

a) If applicable, submit the prospective operator's prior training and experience on Form RSO2to the RSO.
b) Ensure the individual has a Radiographers or an X-ray Machine Operators license.
c) Provide and document training to each new operator on the topics addressed in the Operating Procedures. The Laboratory Hazard Instruction form may be used if the operator will likely receive a total effective dose equivalent of 100 mrem per year.
d) Provide direct (observed) supervision for each operation until the Faculty User is confident that the prospective operator complies with the Operating Procedures and can work independently. The period of supervision depends on the prospective operator’s performance and previous experience with similar devices.
e) When training is complete, add the individual to the Faculty User’s authorization by submitting a memorandum to the RSO for approval/review by the RSC.

3.4.2 MEDICAL RPD OPERATOR RESPONSIBILITIES

a) Operate only RPDs for which approval has been granted. Maintain licensure in accordance with OAC 3701-72-02. Notify the Faculty Coordinator if the operator's license has expired or has been taken away for any reason.

b) Adhere to the safety rules and regulations as promulgated in this manual, facility Operating Procedures, and any communications from the RSC.

c) Wear issued radiation dosimeters when the RPD is operating. Return the dosimeters to the Radiation Safety Officer when use is discontinued.

d) Operate the RPD in such a way as to keep radiation exposures for all personnel, including the patient, As Low As Reasonably Achievable *(ALARA).*

e) Before operating an RPD, visually check and clear anyone from the exposure room who may be unnecessarily exposed to radiation.

f) Ensure that the RPD is secured against unauthorized use.

g) Inform the RSO and the Faculty User immediately of any safety related incident that has or could have resulted in personal injury, even if it occurs after normal working hours.

h) Inform the Facility Coordinator and RSO if any certified components fail. Certified components must be replaced by certified components.

i) Report any malfunctions or unusual operating conditions to the responsible Faculty User and the Facility Coordinator.

3.5 TRAINING FOR BYSTANDERS AND VISITORS

Bystanders and visitors (such as students, maintenance or custodial personnel, and members of the general public) likely to receive a total effective dose equivalent (TEDE) of 100 mrem in a year, must receive instruction in accordance with OAC 3701:1-38-10(B). A Laboratory Hazard Instruction form or training implemented in the facility operating procedures provide acceptable criteria and documentation to fulfill this requirement.

3.6 EXPERIMENTAL PROTOCOLS

3.6.1 PROTOCOL APPLICATIONS

A protocol is a written communication between a Faculty User and the Radiation Safety Committee that briefly describes how the RPD will be used and a commitment to follow the facility operating procedures, as well as any other safety measures that will be taken. The Application for Use of Radiation Producing Devices (Form RSO3A) must be reviewed by the Facility Coordinator and RSO and approved by the Radiation Safety Committee *prior to using* the RPD. The RSO may grant interim approval pending assembly of the committee. The

protocol application must show that anticipated radiation exposures will be consistent with ALARA. Copies of Form RSO3A are also available from the Radiation Safety Office, 104 HS.

The Radiation Safety Committee will review the protocol, specifically considering the adequacy of facility shielding and equipment to be used, operating and emergency procedures, and training and experience of proposed operators. The submitted protocol for use of RPDs will address the topics listed below. Consult with the Radiation Safety Officer (ext. 2169) if you have questions regarding the protocol application.

a) *list the personnel involved*, include a Form RSO2 for operators who have previous training and experience. Ensure they have appropriate training or licensure as specified in the operating procedures.

b) *list all RPDs* that will be used in the study, *type(s) of radiation* (e.g., x-ray, electrons) *and energy*, the *exposure monitoring devices* (e.g., TLD)*, area survey equipment* (e.g., Geiger-Müller detector), and the *location* of the RPD.

c) *briefly describe the proposed use*. Address procedures (specify a commitment to follow the facility operating procedures or address special procedures that will be used), materials or subjects to be irradiated, and safety precautions. Also consider:
   (1) For clinical x-ray units, has approval from the Institutional Review Board been obtained, if required?
   (2) Do you plan to use animals?
   (3) Are any non-radiation concerns for safety evident (e.g., handling high voltages or hazardous chemicals)?
   (4) Is there a potential for ozone or other hazardous gas production? Is the ventilation adequate?

3.6.2 PROTOCOL CHANGES

a) Minor Changes. An example of a minor protocol change is adding or deleting an operator. Minor changes require a memorandum from the Faculty User to the RSO indicating the change and briefly explaining the reason. The RSO may approve the change, subject to review by the Radiation Safety Committee.

b) Significant Changes. Protocol changes where the procedures or project scope differ significantly from the existing use protocols approved by the RSC (e.g., changes from previous operating conditions, shielding changes, change in facility design) require the submission an additional protocol application form (Form RSO3A). The RSO may provisionally approve the change, pending final approval by the Radiation Safety Committee.

c) Protocol Renewal. Biennially, Faculty Users must review their protocols to ensure the information is current and accurate. Faculty Users are encouraged to compare their current laboratory procedures, materials used, and personnel against protocol records. The RSO summarizes the protocol information to facilitate the review.

3.6.3 PROTOCOL SUSPENSION

Faculty Users who are not currently using an RPD, but may do so in the foreseeable future may place their protocol in suspension by informing the RSO in writing. The Faculty User must give ample (i.e., about two weeks) notice to the RSO when RPD usage will be restarted.

3.6.4 PROTOCOL TERMINATION

Faculty Users who plan to discontinue using the RPD or end their university affiliation must terminate their protocols by:

a) informing the RSO of termination plans.
b) returning all facility keys to the Facility Coordinator, Department Chair, or RSO.
c) returning the Radiation Safety Manual and dosimetry to the Radiation Safety Office.

3.7 PROTECTIVE MEASURES FROM EXPOSURE

3.7.1 TIME, DISTANCE, AND SHIELDING

Use of the principles of time, distance, and shielding can significantly reduce personal exposure to levels that are *as low as reasonably achievable* (ALARA). Practical applications include using lead aprons for fluoroscopy and standing clear of primary radiation beams and radiation areas.

a) *TIME*: Radiation exposure can be decreased by reducing the amount of time people spend working in radiation fields.

b) *DISTANCE*: X ray intensity decreases inversely with the square of the distance ($1/d^2$) when the source is small compared to the distance. For instance, if you double your distance from a radiation source, you reduce your exposure by (1/4) one-fourth. The radiation intensity decreases more slowly for large or planar sources.

c) *SHIELDING*: Attenuating material placed in the radiation path can effectively reduce external dose. The thickness of shielding needed is determined by the type and energy of radiation, type of shielding material, distance from the source, time spent in the work area, and acceptable level of dose reduction. The adequacy of the shielding is evaluated by the RSO and verified using a survey meter. The exposure rate to the user should be reduced to 1 mrem/hr or less for long procedures. The exposure rate in any unrestricted area must not exceed 2 mrem/hr. Dose to members of the public must be restricted to less than 100 mrem/year. In the interest of *ALARA* the exposure rate in any unrestricted area should be consistent with background. Information on the attenuating characteristics of shielding materials can be obtained from the RSO.

   Inform the RSO if facility changes (e.g., structural changes, moving an RPD, increasing operating voltage range, construction around the facility) are contemplated or in progress so that the potential impact on shielding can be evaluated.

3.7.2 GENERAL PRECAUTIONS WHEN USING RPDs

- ☐ Never expose fingers, hands, or any other body part to the primary beam. No person may be intentionally exposed to the primary beam, except a patient who has a physician's order or Institutional Review Board approval. This restriction applies to training, demonstrations, and any other non-medical diagnostic purpose.

- ☐ Never disengage a safety interlock (except as described by an approved protocol) or warning device or operate a unit if one of these systems malfunctions.
- ☐ Use time, distance, and shielding to minimize your exposure.

- ☐ Properly wear dosimetry, if issued, whenever the RPD may be energized.

- ☐ Record RPD usage and maintenance in a facility logbook, according to operating procedures.

- ☐ Never energize electrical equipment if the floor or equipment is wet or if high voltage wires are exposed.

- ☐ Never operate equipment for which you have not been trained.

- ☐ Never alter, repair, or perform maintenance on an RPD component without authorization and approval from the Facility Coordinator.

3.7.3 ADDITIONAL PRECAUTIONS FOR MEDICAL RPDs

- ☐ The operator must remain behind the control shield during exposures, when applicable. Persons needed to attend to the patient (e.g., parents) must stay behind the operator's control shield or at least 2 meters from the x-ray tube during the exposure.

- ☐ Use mechanical restraints for difficult patients. If the patient must be held, use a parent (or adult relative) wearing a lead apron. Leaded gloves are required if the restraining person must place their hands near the primary beam. No person will routinely hold patients.

- ☐ Operators must use the fastest screen / film combination. Cassettes without intensifying screens cannot be used.

- ☐ The source-image distance cannot be less than 30 cm.

- ☐ Grids must be installed and used properly.

- ☐ Processing solutions must be made and films must be processed according to manufacturer's specifications. Do not use expired film.

3.8 RPD ACQUISITION

The purchase or receipt of a radiation-producing device shall be coordinated with the Radiation Safety Officer during the early planning stages to ensure that the facility is adequately shielded and the device can be properly registered with the OBRP. An installed RPD may not be operated, other than for controlled, preliminary, installation tests, until all safety interlocks and warning devices are fully operational, administrative requirements have been met, and acceptance tests have been performed by the RSO or other qualified person approved by the RSC.

3.9 LOCATIONS OF USE

Each location having a RPD must be registered by the OBRP. The operation of each RPD is contingent upon verification of the adequacy of shielding, interlocks, warning devices, ventilation equipment, and personnel protection equipment by the Radiation Safety Officer. Inform the Radiation Safety Officer well in advance should it become necessary or desirous to change the location or dispose of an RPD, whether it is operational or not.

3.10 SECURITY

Radiation producing devices will be secured against tampering and unauthorized operation. The controls of the device will be inaccessible, locked, disconnected or otherwise disabled, or positively secured when not under the physical supervision of an approved operator.

In special circumstances, equipment may be operated while unattended, so long as positive security against unauthorized entrance to radiation areas and the operating controls are maintained. Conditions for unattended operation should be clearly stated in the operating manual. Two requirements for unattended operation are:

(1) the entryway must be locked and safeguarded against unauthorized entry and
(2) a notice must be posted at the entryway informing departmental and emergency personnel of necessary precautions and actions in case of an emergency.

3.11 POSTING / LABELING WARNING SIGNS

Warning signs and labels heighten the awareness of persons who may enter the lab and alert them of possible or eminent dangerous conditions. They provide a constant reminder for operators, custodians, and maintenance personnel to exercise caution and responsible action.

3.11.1 POSTING AT LAB ENTRYWAYS

a) Radiation Area. A warning sign bearing the radiation symbol and "Caution Radiation Area" will be conspicuously posted at the entrance to an accessible area where a person could receive 5 millirem (0.05 mSv) in one hour at 30 cm from the radiation source or its shielding.

b) High Radiation Area. A warning sign bearing the radiation symbol and "Caution High Radiation Area" will be conspicuously posted at the entrance to any accessible area where a person could receive 100 millirem (1mSv) in one hour at 30 cm from the radiation source or its shielding.

c) Notice to Employees. Ohio Department of Health form 4786.32 "*Notice to Employees*", must be visibly posted in or near laboratories where RPDs are located.

d) Damaged Signs. The Facility Coordinator will notify the RSO for replacement if any posted form is found to be defaced, altered, or removed.

3.11.2 WARNING ON CONTROL PANEL

The control panel of a radiation-producing device will be labeled with the notice, "Caution: This machine produces radiation when energized." or similar words appropriate for the RPD.

3.12 FACILITY OPERATING PROCEDURES

The Radiation Safety Manual does not address specific concerns for each RPD. As an extension of the RSM, *Operating Procedures* (OP) provide guidance to RPD operators on facility procedures and safety requirements. The Facility Coordinator promulgates the OP. The procedures should be reviewed periodically by the RSO and Facility Coordinator for possible updating or changes. OP must be present in the facility and accessible to all approved operators.

Since each RPD facility has distinctly different levels of concern, the operating procedures must address safety items that are specific to the facility. Any special precautions to enhance safety (e.g., access control, emergency response, usage) should be clearly communicated. The procedures should contain the following information, as applicable or if augmented from the conditions of this manual:

a) a brief description of the facility design and purpose.
b) any limits to operations.
c) training requirements.
d) responsible parties and responsibilities.
e) security.
f) use log.
g) safety interlocks and warning devices.
h) good safety practices.
i) dosimetry requirements.
j) radiation detectors available for use.
k) general safety concerns (e.g., electrical, noxious gases, lifting).
l) maintenance, repairs, system alterations, lock out/tag out procedures.
m) emergency procedures.
n) checklists for start-up, operation, shutdown, testing interlocks and warning devices.

3.13 USE LOG

A record of RPD usage should be maintained to document routine operations and unusual events. The presence of visitors, students, or trainees may be recorded. This record should be retained indefinitely.

a) Routine Entries. Routine entries (depending on the type of unit) may include date, operator, operating parameters (e.g., kVp, mA), duration of exposure, or any other relevant information.

b) Testing of Interlocks. Whenever system interlocks or warning devices are tested, the result of that test must be logged.

c) Maintenance or Repairs. A record of maintenance and repairs should also be maintained. If the unit is inoperable or unsafe to operate, the record should indicate the status and what measures were taken to prevent operation.

d) Unusual Events. Unusual events may include irregular sounds, presence of fumes, vapors, or smoke, malfunction of components, or suspected injury to an individual.

3.14 VENTILATION

Ionization of air from the operation of high-energy particle accelerators may yield noxious gases, such as ozone and nitrous oxide. Significant accumulation of noxious gases can occur in poorly ventilated high radiation areas. Radiation in closed containment vessels can generate especially high concentrations of noxious gases, which must be vented to the atmosphere outside the building. Radiation interaction with some gases, such as SF_6, can increase their toxicity. Irradiation of some solids or liquids may produce noxious decomposition products. Experimental protocols must address such reactions, if applicable, so that the Department of Environmental Health and Safety (EHS) can evaluate the proposal for appropriate controls. The Facility Coordinator will develop procedures, which may include restrictions to operations, based on recommendations by EHS staff for compliance with air quality requirements.

3.15 EMERGENCY RESPONSE

Any unusual event that may injure an individual or damage the RPD or the facility must be handled immediately to prevent the situation from becoming worse. Some potential emergency situations include electrical shock, accidental radiation exposure, fire in the facility or elsewhere in the building, detection of fumes, unusual sounds, water leaks, and smoke.

Situations involving severe or life-threatening injuries can vary significantly. The outcome of an emergency depends largely on the actions taken by the persons present. The following list of actions prescribes general guidance for emergency response. Key to any reaction is for the responder to act calmly and rationally. The operating procedures for each facility may address specific actions expected of operators in the event of an actual emergency. The event should be recorded in detail in the Use Log or by memorandum to the Facility Coordinator and RSO as soon as possible after the situation is under control.

a) **Shut down the RPD**.

b) If personal radiation exposure is suspected, avoid changing the operating parameters. This information may be necessary to reconstruct exposure conditions.

c) **IMMEDIATELY NOTIFY the Radiation Safety Officer, Facility Coordinator, and Faculty User.** The FC or FU will immediately notify the department Chair.

d) **If injuries are suspected:**
   (1) Serious Injuries. The university procedures for injuries and illnesses are outlined in Wright Way Policy 6031. Immediate assistance for serious injuries should be sought. On the main campus call the Public Safety Communications Center by dialing 2111 or 911, or use any emergency telephone located in the corridors throughout the campus. For off-campus laboratories, either use the medical facilities immediately available or call the local paramedics for assistance.
   (2) Minor Injuries. Consult Wright Way Policy 6031.

e) **Ensure the unit cannot be used** until the problem is resolved by removing facility keys. Post a "DO NOT USE" sign on the console, if circumstances permit. Only the FC can remove a “DO NOT USE” sign. Disconnect the system from the electrical power, if safely feasible.

3.16 EXPOSURE RATE MONITORING

Facilities that have portable survey meters for area monitoring should use them periodically to verify the radiation exposure levels in occupied areas are consistent with ALARA. More frequent surveys may be required by facility procedures. If an operator questions whether radiation production has ceased, a survey of potential exposure must be made prior to entry.

a) Meter Appropriation. Facility Coordinators are encouraged to acquire their own instruments for routine use from research or departmental funds. Survey meters are available for a wide variety of uses. The Radiation Safety Office can assist researchers with selection of the appropriate instrument for the intended purpose. For special applications, survey meters that are satisfactory for most purposes are available on loan from the Radiation Safety Office.

b) Calibration / Repair. Survey meters must be calibrated annually. The Radiation Safety Office provides this service. The cost of repair or replacement of instruments damaged through misuse or careless handling is the responsibility of the laboratory. The calibration should be verified after significant repairs are made or the detector’s response to radiation is questioned.

c) Operational Checks. Prior to use, the survey meter should be checked to ensure it is operating properly. Check the:
   (1) *Battery condition*. If low, change the batteries. Consult the RSO if you have questions. Changing the battery does not require calibration.
   (2) *Calibration label*. The instrument must be calibrated within 1 year.
   (3) *Meter response*. Ensure the meter responds properly to the source on the side, if applicable.

d) Monitoring Procedures. Use the open window part of the probe for maximum detectability. Move the detector slowly. Using the audio (if available) facilitates detection at background levels. Sporadic counts may be due to cable movement. Areas where this occurs should be monitored again with the detector movement

suspended until the reading can be made. Log results that are distinguishable from background. If results exceed 2 mR/hr, notify the Facility Coordinator and RSO.

3.17 FACILITY EVALUATIONS

The Radiation Safety Officer surveys each facility containing radiation-producing equipment soon after installation to ensure compliance with OBRP rules. The survey will evaluate administrative and engineering controls, such as interlocks, warning devices, operating and emergency procedures, security, and shielding. Radiation exposure levels in areas that may be occupied during operation are also recorded. Each facility will be re-evaluated either annually or as required. Surveys will also be conducted when significant modifications are made to the facility or near the facility that may affect the integrity of shielding. The Facility Coordinator must notify the Radiation Safety Officer when such changes are expected or suspected.

The survey results are reported to the Facility Coordinator who will ensure corrective actions are made. If the facility is considered unsafe to operate, the Facility Coordinator will ensure that the facility is closed and positive measures are taken to prevent operation until repairs rectify the problem.

The OBRP inspects each operational unit periodically. For most RPDs this period is every three years. Bills for this service are forwarded to the respective department for payment. Timely remittance is encouraged. If these bills are not paid within 90 days of the invoice date, the fee doubles.

3.18 TESTING OF SAFETY DEVICES

3.18.1 ROUTINE TESTING

The proper function of safety interlocks, visible and audible warning devices, emergency interrupt devices, radiation level monitors and key-lock or security shutoff switches will be verified at least:

a) once each month or prior to each use when the device is not routinely operated, whichever is later; or
b) prior to use after maintenance, repairs, or alteration that may affect safety device operation.

A record of the verification, observations and description of any repairs found necessary will be entered in the facility's use log.

3.18.2 SAFETY DEVICE FAILURE

Any time a safety device fails to operate properly, all operations in the facility must be immediately terminated. Implement lock out/tag out procedures (if applicable). Post a "DO NOT USE" sign on the console and make an entry in the Use Log regarding the failure. The Facility Coordinator must be notified. The RSO must be notified if anyone has or may have received an unplanned radiation greater than the ALARA levels. Once the problem is corrected, the safety devices will be tested again and results logged. The "DO NOT USE" sign

can be removed by the Facility Coordinator when the safety devices are shown to be operational.

3.18.3 SAFETY DEVICE BY-PASS

No safety or warning device may be defeated or by-passed during routine operation. Jumpers, interlock plugs, or other devices that may defeat safety or warning systems will be conspicuously tagged and a notice of its installation posted (e.g., a "DO NOT USE" sign, implement the university lock out/tag out procedures) at the control panel of the radiation-producing device. An entry in the Use Log must be made stating which safety device(s) has been over-ridden and for what purpose. After service or repair has been completed, the safety and warning equipment will be tested to verify proper operation. A log entry will be made stating that the facility is fully operational and safety devices have been tested. Only the Facility Coordinator may remove a "DO NOT USE" sign.

3.19 MAINTENANCE AND REPAIRS

The Facility Coordinator must authorize all repairs, maintenance, and facility alterations. Any change that may affect personal safety or radiation exposure, facility design, or shielding must be submitted to the Radiation Safety Officer for evaluation and to the Radiation Safety Committee for approval.

Maintenance and repairs may only be made by manufacturer representatives, contracted maintenance and repair specialists, or persons approved by the Facility Coordinator who have the training and experience to make repairs safely. The Facility Coordinator must approve the procedures for maintenance and repairs. Implement "lock out/tag out" procedures, if applicable. A "DO NOT USE" sign must be posted on the unit's console and a log entry made to record the respective repairs. When the unit is operational and the safety interlocks are tested, a log entry is made. Only the Facility Coordinator may remove the "DO NOT USE" sign when the facility is fully operational.

3.20 DISPOSAL OF RADIATION-PRODUCING EQUIPMENT

The Facility Coordinator must notify the RSO whenever a RPD is planned for disposal or permanently disabled so that proper administrative procedures may be followed. Radiation-producing equipment may be disposed by transferring the unit to another facility by sale or donation or scrapping it as waste.

The OBRP must be notified of the disposition of the unit and the state registration may need modification. If the unit is transferred to an Ohio facility, the RSO should inform the new owner of the need to register the device. If the unit is disposed as scrap, the x-ray tube(s) must be de-activated and any hazardous chemicals or materials treated or removed.