Radiation Safety Manual

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1.0 Introduction

The purpose of this manual is to present regulations, recommended procedures and practices for working with radiation sources at the University of Illinois at Urbana-Champaign. The regulations, procedures, and practices are designed and administered to protect the individual, prevent the spread of contamination, and assist the university in fulfilling its responsibilities to its students, staff, and neighbors.

This manual is designed to help staff members perform teaching, research, and public service with radiation sources in a safe, legal, and efficient manner. It is a general resource on rules, procedures, and responsibilities for working with radiation. The manual is not all inclusive. Because of the wide variety of radiation sources, facilities, research methods, and situations; it is impossible to anticipate and address all eventualities within the scope of this manual. Communication between users of radiation sources, the Division of Research Safety (DRS), and the Radiation and Laser Safety Committee (RLSC) is essential to the responsible and beneficial use of radiation sources. Written primarily for personnel working with beta/gamma-emitting radioactive material, additional requirements may be necessary for work with radioisotopes that decay by alpha emission or by spontaneous fission. Radioactive materials containing natural radioactivity in concentrations that do not exceed the activity of natural potassium (10^{-9} curies/gram) are exempt from regulatory control.

The individual radiation user is responsible for understanding and conducting operations in a manner to minimize hazards to self and others.

The principal investigator (PI), also referred to within this manual as "laboratory supervisor" or "permit holder," is responsible for ensuring that all personnel in his/her area receive instructions on the nature of the radiation hazards and the necessary radiation safety procedures in the laboratory. Radiation workers must possess the necessary skills and disposition to cope with radiation safety problems.

The Division of Research Safety (DRS) provides consultation and services related to radiation safety to users and laboratory supervisors.

The Radiation and Laser Safety Committee (RLSC), a standing committee of the Office of the Chancellor, is responsible for establishing policies for the Radiation Safety Program, for reviewing the work of DRS staff, and for advising them and the radiation users on specific problems.

All individuals using radiation sources, and their supervisors, must familiarize themselves with the portions of this manual that apply to their operations.

Appendix A of this manual gives a more detailed description of these responsibilities.

2.0 Authorization of Ionizing Radiation Sources

Individuals who want to acquire (buy/procure/purchase; receive by loan, gift, or transfer), possess, or use radioactive materials must apply for and be approved for a Radiation Permit issued by DRS. A permit is also required for technologically "enhancing" naturally occurring radioactive material. This section of the manual discusses the application process, responsibilities for maintaining a permit, steps to amend or terminate a permit, and the policy on abandoned radioactive materials.

2.1 Radiation Permit Application Process

Appendix E of this manual has a copy of the Radiation Permit Application. Complete the application and submit it to DRS.

DRS reviews the application, prepares a radiation permit specifying the quantities, locations and conditions for use of radioactive materials, and obtains the approval signatures of the campus Radiation Safety Officer (RSO) and the Radiation and Laser Safety Committee Chair. The permit is returned to the applicant in duplicate. The PI and his or her unit head must sign and return one copy of the permit to DRS, acknowledging their acceptance of the responsibilities associated with the permitted activities. The other copy of the permit is retained by the PI and must be made available to persons using radiation sources under its provisions.

Once all signatures have been obtained, the permit is in effect and acquisition of radioactive materials may commence (see section 4.0). Before operations under the permit commence, DRS personnel will inspect the laboratory to ensure that the area is properly posted, training has been completed, waste cans and radiation detectors are available, and other conditions specified in the permit are met.

2.2 Radiation Permit Validity

A permit is valid as long as the conditions in the permit are fulfilled and there is a need for radioactive materials in the laboratory. In some cases, a PI may need a radiation permit for a specified period of time. At the end of that time, the permit should be deactivated in accordance with section 2.4. If no radioactive material usage is planned for several months or more, the PI should request that the permit be deactivated.

2.3 Amendments

A permit can be amended at any time, e.g., to include additional types or quantities of radionuclides. To do this, the PI sends a written request describing the desired change to DRS. DRS evaluates the change. If the amendment is approved, the RSO authorizes the new permit, and a copy is sent to the PI. Additional signatures are not required.

2.4 Deactivating/Reactivating a Permit

A laboratory must be free of any radioactive material (in the form of contamination, source vials, waste or stored samples) before a permit can be deactivated. Radioactive material must be properly disposed or transferred to another laboratory with an authorized permit as described in Section 4.3. Laboratory personnel should perform surveys to ensure that no contamination exists in the lab. Once surveys have shown that the laboratory is free of contamination, laboratory personnel should remove or deface radioactive labels and markings with the exception of door signs (only DRS personnel can remove door signs). Contact DRS to perform a final survey and to have the radioactive material postings removed from the laboratory entrances. The permit is deactivated when all areas have received a satisfactory final survey and postings have been removed.

A PI can simply reactivate a previously deactivated permit by contacting DRS. No additional signatures are required to reactivate a permit.

2.5 Abandoned Radioactive Materials

Unknown and/or abandoned radioactive materials and/or radioactive contamination must be properly managed and effective decontamination must occur in a timely manner.

Campus units are responsible for decontaminating facilities and equipment assigned to their unit. Additionally, campus units must identify and properly dispose of radioactive materials abandoned by their personnel.

Situations may arise in which unknown or abandoned radioactive materials and/or contamination are discovered. In such cases, the campus unit is responsible for performing detailed analyses and properly disposing of such materials and/or reducing contamination to acceptable levels as defined by regulatory limits. If a campus unit is not able to assume these responsibilities or perform these required tasks within a reasonable time frame, it may enlist the services of a qualified outside vendor or DRS on a cost-reimbursement basis.

If unknown or abandoned radioactive material or contamination is discovered, DRS will make, in writing, a request to the responsible campus unit to complete cleanup within 60 days. After 60 days, DRS may assume responsibility and proceed to complete the task unless DRS and the responsible campus unit agree otherwise. The campus unit will reimburse DRS for the costs incurred in the process. The Radiation and Laser Safety Committee will arbitrate any disputes that may arise.

Further questions concerning this policy should be directed to DRS, telephone 217-333-2755.

3.0 Radiation Safety Training Requirements

3.1 Radiation Safety Training

Regulations, based on laws for working with radioactive materials, require that users of radioactive materials be properly trained. Each PI is responsible for providing radiation safety training to persons using radiation sources under his or her supervision at intervals not to exceed 12 months. The PI must ensure that this training is completed and documented.

3.2 Radiation Awareness Training

Regulations also require each PI to provide awareness training at intervals not to exceed 12 months for anyone who frequents radioactive materials locations that are under his or her supervision.

Other individuals may provide the training under the supervision of the PI. DRS has developed web-based training modules that give a general background in radiation safety and can provide general training to personnel upon request.

3.3 Training Content

Individuals shall be instructed in the following before working with radioactive materials:

- Health protection problems associated with exposure to radioactive materials or radiation;
- Precautions or procedures to minimize exposure;
- Purposes and functions of protective devices employed;
- The permit conditions and the applicable portions of the Radiation Safety Manual;
- Employee responsibility to promptly report any condition that may lead to or cause a violation of the regulations or cause an unnecessary exposure;
- Actions to take in the event of an emergency; and,
- Radiation exposure reports that workers may request.

Particular attention should be given to contamination survey requirements, dosimetry requirements, necessary documentation, safety precautions/equipment, authorized radionuclides, possession limits, precautions during pregnancy, and locations where radioactive materials are authorized. Regulations require that this knowledge be reinforced by annual radiation safety training.

The extent of the instruction shall be commensurate with the potential radiological health problems in the work area.

Records of this instruction must be maintained by the PI for audit by DRS personnel or for inspection by state regulatory personnel.

4.0 Procurement and Transfer of Radioactive Materials

4.1 Ordering Radioactive Materials

Only holders of current radiation permits may order radioactive materials. The permit specifies the conditions, limitations, isotopes and quantities, under which the approved user may possess and use the specific radioisotopes being purchased.

To purchase radioactive materials, the PI submits a completed university purchase requisition to his/her business office. The purchase requisition should be labeled *"Radioactive Material."* The PI's campus unit must initiate a purchase requisition or standing purchase order for the radioactive materials in the Banner or I-Buy System. Then the unit must enter the applicable information into DRS radioactive material purchasing database for final authorization. DRS database may be accessed from:

http://www.drs.illinois.edu/

To ensure expeditious handling of the order and avoid delays to their shipment, the PI should provide the following information on the university purchase requisition:

a. The name and signature of the PI responsible for the materials;
b. The isotope being ordered;
c. The amount of activity in millicurie (mCi) or microcurie (μCi) units being ordered; and,
d. The chemical form of the isotope being ordered.

Unless previous arrangements have been made, all radioactive materials shall be shipped to:

Division of Research Safety
Special Materials Storage Facility MC 612
2006 South Griffith Drive
Champaign, IL 61820
United States

4.2 Receipt of Radioactive Materials

Unless prior arrangements have been made, DRS receives all campus orders of radioactive material. DRS monitors all shipments in accordance with regulations established by the Illinois Emergency Management Agency (IEMA). After each shipment of radioactive materials has been checked and found to be in compliance with all applicable rules and regulations, DRS personnel deliver it to the user's laboratory during workdays, usually between 10 a.m. and 2 p.m.

DRS provides a *Radioactive Material Receipt Record* for each package delivered. The person accepting the material is asked to sign for the package(s).

When opening a shipment of radioactive materials, use personal protective equipment (PPE, e.g., gloves, lab coat) and utilize radiation badges, as appropriate. Laboratory personnel must survey all radioactive materials labeled packages to check the inner package and final source container and determine whether leaking has occurred. Shipments containing materials that may be volatile, gaseous, or readily dispersible shall be opened in a fume hood. Check and verify that the contents received are exactly what was ordered and match the shipment packing slip. The user shall notify DRS immediately if there is a problem with the shipment.

If there are no problems with the shipment, enter/log pertinent data in a Radioisotope Use and Waste Log (see Appendix E).

Ensure that the received radioactive materials are properly stored and **secured**.

Laboratory personnel must dispose of the shipping material in an appropriate manner. If contamination is present, place the material in a radioactive waste container. If the shipping material is free of contamination, remove or deface any "radioactive materials" labels or markings on it and dispose of it in the regular trash or recycle.

4.3 On-campus Transfers of Radioactive Materials

Transfers of radioactive materials within the campus may occur between mutually agreeable PIs after authorization by DRS. These are regarded as “on-campus” transfers. A PI is not permitted to dispense radioactive materials on a routine basis to other researchers. DRS will approve procedures for recurrent transfers of radioactive materials over a period of time on a case-by-case basis. The following describes the steps to transfer radioactive material:

GIVER:

1. Request permission by contacting DRS with the following:
   a. Radiation permit number and name of the individual to receive the materials;
   b. Location where materials will be used/stored by the recipient;
   c. Isotopes and amounts (mCi) to be transferred.

2. Ensure that the material is properly packaged for transport.

3. Maintain written records of all transfers, including isotopes, amounts, dates, and documentation of contamination surveys of packages.

RECEIVER:

Maintain accurate records of the receipt (isotope, quantity, date, from whom that material was received). Ensure that the radioactive material is stored properly.

4.4 Off-campus Transfers of Radioactive Materials

Transfers of radioactive material to off-campus personnel may be done only via DRS. DRS personnel ensure that the radioactive material is properly packaged and in compliance with shipping regulations. All such shipments are handled on a case-by-case basis. Contact DRS personnel at 217-333-2755 for assistance.

4.5 Transfers of Radioactive Materials from Off-campus

Occasionally, a PI may receive radioactive material as a gift from another campus or institution where a purchase order is not involved. In such cases, the PI must make prior arrangements with DRS for purposes of license verification, radiation permit authorization, and receipt instructions.

The most current information regarding the procurement and transfer of radioactive materials at the University of Illinois at Urbana-Champaign can be found at:

http://www.drs.illinois.edu/Programs/ObtainingRadioactiveMaterials

5.0 Using Radioactive Materials

5.1 Storage of Radioactive Materials

Radioactive materials must be secured at all times.

This may be accomplished by *any* of the following:

1. Attending the materials;
2. Maintaining materials in a locked freezer or cabinet; or,
3. Locking the room in which the materials are stored.

These requirements apply to **ALL** radioactive materials in the laboratory, including waste, contaminated equipment, and sealed sources.

Radioactive materials stored in occupied areas shall be shielded in accordance with the ALARA principle (i.e., radiation exposures to faculty, staff, students and the public resulting from the use of radiation sources in teaching and research shall be kept As Low As Reasonably Achievable (ALARA)), which is discussed in Sections 7.8 and 7.9.

Unbreakable containers are recommended for storing radioactive liquids. Glass or fragile bottles and other breakable containers used for storage must be kept in non-breakable, leak-proof secondary containers or trays capable of containing the entire volume of liquid stored in the primary container.

Radioactive gases and volatile forms of radioisotopes should be stored in a well-ventilated area, such as a fume hood.

Sealed sources **must** remain in the same condition as received from the manufacturer.

No modification of sealed sources is permitted without express written consent from DRS.

Sealed sources that have been mutilated and damaged beyond what would reasonably be expected to occur as a result of its normal use should be reported to DRS as soon as possible.

Radioisotopes and calibration sources shall be clearly labeled with the following information:

Caution: Radioactive Materials
Radionuclide
Activity and assay date
Person responsible for sample or source

Labeling is *not* required if the activity is less than the following:

Nuclide	Quantity (μCi)
H-3	1000
C-14	1000
P-32	10
P-33	100
S-35	100
Tc-99m	1000
I-125	1
I-131	1

Exemptions for other radionuclides may be found in Appendix C of the Code of Federal Regulations, Title 10, Part 20:

http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-appc.html

5.2 Using Radioisotopes in Animals

When radioisotopes are used in animals, the areas in which animals are kept must be posted in accordance with the requirements of IEMA statutes and regulations.

Cages and pens must bear labels listing the isotope used, the quantity and date administered, measured external radiation levels, and the name of the PI. These cages and pens should be separated from those housing non-radioactive animals.

Ventilation should be adequate to handle the possibility of airborne radioactivity. In some instances, this may require the use of a fume hood or self-contained, controlled environmental systems.

Procedures for disposal of animal excreta must be included in the radiation permit application process. If excreta are mixed with bedding materials, handle in accordance with dry radioactive waste procedures.

DRS must approve disposal methods for animal carcasses.

Animal caretakers shall be instructed and trained by the PI on handling procedures, dose levels, occupancy time limits, and applicable special conditions. Animal caretaking should be performed by trained research personnel.

Authorization to administer radioisotopes to animals shall be approved by DRS. DRS establishes the criteria for releasing the animals to the owners.

6.0 Emergency Procedures

In any radiation emergency, personnel protection comes first, confinement of radioactivity next.

In an emergency, from a safe location, immediately call 911 (METCAD). After emergency notifications have been initiated contact DRS at 217-333-2755 (3-2755 from campus phones) to contact the RSO who will provide assistance to first responders as requested.

Refer to the guidelines in this section to determine emergency situations requiring immediate action and support from outside personnel.

These guidelines are intended to help users to develop a safety-oriented attitude, actively anticipate and work to prevent potential hazards and accidents and to respond appropriately to unexpected events. The PI may find it useful to draw up a written emergency plan suited to his/her own facility and operations. The PI should make the specific equipment and supplies required to minimize hazards and enhance recovery readily available. For example, chemical compounds in use might require special decontamination agents.

6.1 Serious Injury and Exposure or Contamination

If someone has received high radiation exposure or radioactive contamination in addition to physical injury requiring immediate medical assistance, call 911 (METCAD). Inform emergency personnel that the patient "needs emergency medical attention and is/might be contaminated with radioactive material".

If possible, someone familiar with the incident should accompany the injured person to provide information such as the nature of the injuries, radiation levels, and the physical and chemical nature of the contamination. Also, follow instructions listed in 6.4 for Intermediate and High-Level Spills.

6.2 Fire or Explosion in a Radioisotope Area

In case of fire or explosion, immediately evacuate and if safe to do so, activate fire alarms. Call 911 (METCAD). If possible, stay on the scene at a safe distance to provide the incident commander with information on the nature of the radiation hazards present (identity, location, and activity of radioactive sources) and to assist as requested. Also, follow instructions listed in 6.4 for Intermediate and High-Level Spills.

6.3 High Radiation Exposure *without* Contamination or Physical Injury

Do what can be done to terminate or limit the exposure and to prevent others from being exposed. If there is a significant exposure to all or any part of the body, notify the campus radiation safety officer at 217-333-2755 (3-2755 from campus phones).

6.4 Intermediate and High-Level Radioactive Spills

In case of a serious accident involving contamination of personnel or equipment (including 6.1 and 6.2), the following steps should be taken in the order listed.

1. Protect Personnel
   a. If the hazard is extreme (high radiation level or possibility of air contamination), evacuate the area immediately and close and lock the door. Leave behind any contaminated (or suspected contaminated) clothing or other articles.
   b. Rid the victim of contamination: Remove contaminated clothing and wash contaminated parts of the body thoroughly with mild detergent. Bag contaminated items.
   c. Flush out any wounds with copious amounts of water.
   d. Warn fellow workers and keep others out of the area.

2. Confine Contamination
   a. Localize the spill area. Turn containers upright that have tipped over and place absorbent material at edges of liquid spills.
   b. Do not spend time in the area of a dry spill without respiratory protection. Utilize respiratory protection ONLY if you have been trained in the use of respiratory protection AND properly fit tested to wear the specific respiratory protection assigned. Shut off or close the ventilating system if possible and turn off fans and blowers on hoods.
   c. Minimize the spread of contamination. Remove shoes or put on shoe covers at the edge of contaminated area when summoning help.
   d. If contamination is widespread outside the laboratory, it may be necessary to call the University Police (217-333-8911) to assist in establishing traffic control.
   e. Check all objects and clothing for contamination before leaving the area. This includes clothing, tools, equipment, or other personal effects not worn during the accident.
   f. Call DRS (217-333-2755) as soon as possible.
   g. In all cases, consult the Emergency Call List posted in each radiation laboratory.

3. Decontaminate
   a. Abortive attempts at decontamination can make things much worse. Unless immediate action is required to safeguard personnel and equipment, decontamination must occur under the supervision of DRS and emergency personnel.

b. DRS will determine the procedures and equipment to be used and provide assistance as necessary.
c. All personnel, equipment and areas involved in a radiation spill or release must be monitored to ensure adequate decontamination before normal work is resumed.

After the emergency has passed, the individuals involved shall cooperate fully with DRS personnel in an incident investigation.

7.0 Personnel Exposure Monitoring

7.1 Occupational Exposure Limits

1. The annual limit for occupational workers is the more limiting of:

    a. The total effective dose equivalent = 5,000 millirem (0.05 Sv); or
    b. The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue (other than the lens of the eye) = 50,000 millirem (0.5 Sv).

2. The annual limits to the lens of the eye, to the skin, and to the extremities are:

    a. Eye dose equivalent = 15,000 millirem (0.15 Sv)
    b. A shallow dose equivalent = 50,000 millirem (0.5 Sv)

7.2 Non-Occupational Exposure Limits (Members of the Public)

Each user of radioactive material shall conduct operations so that:

1. The dose in any unrestricted area from external sources does not exceed 2 millirem (0.02 mSv) in an hour.

2. The total effective dose equivalent to individual members of the public from a licensed operation, exclusive of the dose contribution from a licensee's disposal of radioactive material into sanitary sewerage, does not exceed 100 millirem (1 mSv) in any year.

7.3 Declared Pregnant Workers Exposure Limits

The dose limit to an embryo/fetus during the entire pregnancy due to occupational exposure of a declared pregnant woman is 500 millirem (5 mSv). Care shall be taken so that no more than 50 millirem (0.5 mSv) be received during any one month during a declared pregnancy. Efforts shall be made to avoid substantial variation above the uniform monthly exposure rate to a declared pregnant woman (see Appendix B for additional information).

If the pregnant woman has not notified DRS of her estimated date of conception, the dose to the fetus shall not exceed 50 millirem (0.5 mSv) per month during the remainder of the pregnancy.

If, by the time the pregnant woman informs DRS of the estimated date of conception, the dose to the embryo/fetus has exceeded 450 millirem (4.5 mSv), the limit for the remainder of the pregnancy shall be 50 millirem (0.5 mSv).

8.4 Liquid Waste

There are two main types of liquid radioactive wastes generated by research laboratories. The most common liquid waste is aqueous, in which the waste materials are dissolved in water. Such waste may be disposed of by dispersal into the sewage system if concentration limits are low enough. Designate and label a sink for this purpose. The pH range of any aqueous waste shall be adjusted to between 6.8 and 8.0. Aqueous wastes shall not exceed the following concentrations:

Radionuclide	Concentration (μCi/ml)
H-3	1×10^{-2}
C-14	3×10^{-4}
P-32	9×10^{-5}
P-33	8×10^{-4}
S-35	1×10^{-3}
I-125	2×10^{-5}
I-131	1×10^{-5}

Other radionuclide concentration limits can be found in Title 10, Code of Federal Regulations, Part 20, Appendix B, Table 3.

The other, less common form of liquid radioactive waste is composed of volatile, flammable, toxic or organic material that cannot be disposed of through the sewage system. Water insoluble organic solvents shall not be released into the sewage system under any circumstances. (Toluene and xylene-based liquid scintillation cocktails and some HPLC fluids fall into this category. Users are advised to use water-soluble fluids whenever possible). *Non-aqueous waste shall be free of all filterable solids.* For filtering liquid scintillation waste, a 60-mesh metal screen is recommended. Organic, water-insoluble liquid waste is then collected by DRS personnel for disposal. Non-aqueous waste shall be stored in spill-proof, unbreakable plastic containers of either six or ten liter capacities.

Liquid wastes that do not fit into the above categories must be treated on a case-by-case basis. See also Section 8.7 *Mixed Wastes*

CAUTION:

Problems involving chemical reactions between mixtures of liquid wastes may occur. Disposing of cyanides in acidic liquid waste will produce hydrogen cyanide, a very toxic gas. Special care must be taken when disposing of tissue that has been digested in nitric acid, as oxides of nitrogen may be formed that could cause the waste container to explode. The PI must ensure that chemical reactions will not occur in liquid waste containers.

Improperly prepared or packaged radioactive waste that during movement or handling will pose an unacceptable hazard to workers, other members of the campus community, or the public must be immediately corrected before pick-up by DRS personnel can occur. Improperly packaged radioactive waste must not be left uncorrected.

Prior to pick-up by DRS, each container must have a completed *Radioactive Waste* tag attached to it. These tags are available from DRS. Appendix B gives instructions for completing these tags. When waste has been properly prepared, logon to DRS website at: http://www.drs.illinois.edu/ and complete the online pickup request.

8.5 Animal Carcasses

Radioactive material used in animals must be handled on a case-by-case basis. PIs planning to administer radioactive material to animals should contact DRS for guidance concerning the disposal of carcasses.

Animal tissues containing 0.05 µCi or less of H-3, C-14, or I-125 per gram of animal tissue averaged over the weight of the entire animal can be disposed of as if it were not radioactive. However, animal tissue in which radioactive materials have been introduced *shall not* be disposed in a manner that would permit its use either as food for humans or as animal feed, such as rendering.

8.6 Unacceptable Methods of Radioactive Waste Disposal

No freestanding liquids, lead, sharps, or animal carcasses/tissue may be disposed of in solid wastes.

Under no circumstances shall personnel bury radioactive waste in the soil.

Under no circumstances shall *non-aqueous* radioactive waste be released into the sewage system.

Aqueous radioactive liquids in excess of the concentrations specified in Section 8.4 shall not be released into the sewage system. The liquid must either be held for decay or turned into dry waste and packaged appropriately.

Carcasses or animal tissues in which radioactive materials have been introduced *shall not* be disposed of by rendering (a manner that would permit its use either as food for humans or as animal feed).

If the waste contains C-14 or H-3 isotopes in addition to anything listed above, the following procedures should be followed:

8.8 Radioactive Mixed Waste - Generator Responsibilities

1. Initiate a chemical/mixed waste request at: https://www.drs.illinois.edu/chemicalwastepickup

2. A copy from the liquid scintillation printout for the particular waste should be submitted to the DRS personnel picking up the waste. A calculation of the isotopic concentration (in μCi/ml) and total activity (μCi) for the waste is required. If there are multiple wastes, a copy of the printout with calculations should be submitted for each waste.

DRS personnel are responsible for the pickup and disposal of mixed wastes from campus laboratories.

Appendix A: Responsibilities for Radiation Safety

The U of I strives to maintain a safe and healthy working and learning environment for faculty, staff, students, and visitors. The cooperation of the entire campus community is needed to realize this goal. This is particularly true of research and teaching that involves radiation sources, where the Campus Radiation and Laser Safety Committee, and radiation safety officer (RSO), principal investigators (PIs) and department heads, and laboratory workers share the responsibility for creating and maintaining a safe workplace.

Radiation and Laser Safety Committee Responsibilities

The Radiation and Laser Safety Committee advises the Chancellor through the Vice Chancellor for Research and the Division of Research Safety (DRS) on matters related to the campus Radiation Safety Program. The Committee is composed of academic staff and faculty members representing various areas of research and teaching, and members who represent the campus administration including the campus RSO.

The chancellor delegates authority to the committee to oversee the use of radiation sources throughout the campus. The committee has the authority to permit, deny, or revoke authorization for individuals to obtain and use radiation sources at the University of Illinois at Urbana-Champaign.

The responsibilities of the Radiation and Laser Safety Committee include the following:

1. Review proposals for unusually hazardous uses of radiation sources as deemed by the RSO, and establish criteria for equipment and procedures to ensure employee, student, and public safety.

2. Review cases that involve repeated infractions of the rules and regulations for protection against radiation, including lasers.

3. Review accidents that may involve exposure or serious economic loss and other cases for which reports to outside regulatory authorities are required.

4. Review public relation problems that involve radiation sources and lasers.

5. Review appeals from radiation users and modify rules or the decisions of DRS personnel where necessary.

6. Meet formally as often as necessary, but at least four times per year, to review the campus radiation safety program with DRS personnel.

7. Recommend the establishment or modification of campus radiation and laser safety policies.

8. Work with DRS to effectively use electronic communication to keep committee members abreast of unusual events between committee meetings.

9. Review communications between DRS and government agencies that affect the campus radiation safety program and the campus radioactive materials license.

Division of Research Safety and Radiation Safety Officer Responsibilities

1. Provide advice and assistance to all concerned on all aspects of radiation safety.

2. Approve proposals for procurement, use and transfer of radiation sources except proposals involving unfamiliar or extreme hazards that DRS judges as requiring review by the Committee.

3. Receive and monitor all shipments of radioactive materials, deliver acceptable incoming shipments to the consignee, and ensure that outgoing shipments conform to shipping regulations.

4. Maintain permanent records of receipt, use, transfer, and disposal of radioactive materials.

5. Supervise and assist in disposal of radioactive wastes.

6. Assign personnel monitoring devices (e.g., film badges, dosimeters) when necessary, give instructions in their use, and maintain personnel monitoring records.

7. Check radiation monitoring and survey instruments for proper operation and calibrate as often as necessary.

8. Assist in designing and selecting equipment, shielding, and facilities and in the formulating operating procedures for new or modifying existing installations or buildings.

9. Calculate the levels of radiation intensity, time limits of personnel exposure, and minimum working distance around accelerators, reactors, X-ray machines, and other intense radiation sources.

10. Perform and keep records of leak tests on sealed sources.

11. Make and keep records of systematic surveys in areas where the presence of radiation or contamination of surfaces, air, or water is suspected, and notify the area supervisor of the results. In some cases this may require detailed monitoring of an operation from beginning to end by a DRS member.

12. Report hazardous radiological conditions promptly to the individual responsible and, when necessary, to the immediate supervisor and the Radiation and Laser Safety Committee.

13. Supervise and assist in decontamination of all but minor spills.

14. Schedule routine medical examinations in accordance with established policy; help establish criteria, and make arrangements for such examinations as may be required in emergency situations.

15. Enforce all written directives of the committee.

16. Stop any operation or deny access of any individual to radiation sources in the interest of safety. Such action must be reported verbally and in writing to the committee as soon as possible.

17. Grant exemptions to the rules (or impose more stringent restrictions) in emergency situations when, in the judgment of DRS, such action is necessary to reduce risk of serious injury or economic loss. Such actions must be reported verbally and in writing to the committee as soon as possible.

18. Maintain files of federal, state, and local licenses and registrations concerned with radiation sources and initiate applications for renewals and/or amendments of same.

19. Determine whether a radiation incident requires a report to any governing body and prepare such reports for the approval of the committee. Exception: If an immediate report is

required, the campus radiation safety officer shall (with knowledge and approval of the chairman if possible) file such report with the appropriate authorities and shall provide copies to the committee.

20. Be familiar with the federal, state, and local laws relating to radiation and be aware of changes in such laws as they occur. Inform the committee when such changes make modifications of policy desirable and institute necessary changes in the radiation safety program.

Principal Investigator/Unit Head Responsibilities

In addition to assuming all the responsibilities of an individual radiation user, the PI shall:

1. Be responsible for ensuring that all personnel, particularly new personnel, who have access to radiation sources under his/her jurisdiction, are properly instructed and that they possess the necessary skills and disposition to cope with radiation safely. The minimum training requirements are outlined in section 3.0.

2. Determine the types of radiation sources, equipment, facilities, and procedures needed for his/her work.

3. Comply with all radiation permit requirements.

4. Ensure that the procedures for purchase, acquisition, use, and transfer of radioactive materials are followed in work under his/her supervision. This includes keeping accurate inventory and disposal records.

5. Routinely check protective equipment and instruments to ensure they are working properly and adequately performing their intended functions.

6. Work with DRS to solve radiation safety problems unique to his/her situation and to correct violations of federal, state or local rules and regulations.

7. Assist DRS in complying with existing laws and license requirements (maintenance of records, preparation of reports) by providing necessary information and assistance.

8. Obtain the prior approval of the campus radiation safety officer before individuals age 18 and under are allowed to work in a radiation laboratory.

9. When away from campus for an extended period, ensure that radioactive materials and work involving radiation sources receive adequate supervision. A PI that will be absent from his or her laboratory for a period of three months or more must designate a temporary supervisor and inform DRS in writing of this designation. The education, training, and administrative authority of the person designated as temporary supervisor must be sufficient to ensure that all safety requirements will be met and must be acceptable to DRS.

10. Inform DRS of an intention to cease using radioactive material, an extended departure from campus is planned, or if there is any reason the obligations in this manual cannot be met.

11. Report lost, stolen, or missing sources of radiation to DRS. DRS is required to notify state regulators within 24 hours after when the absence becomes known.

Unit heads shall inform DRS whenever any radiation permit holder of their unit will be absent from campus for more than three months and whenever there are circumstances that might require additional assistance from DRS (e.g., temporary disability).

Worker Responsibilities

The individual user has the final responsibility for the safe use of the radiation sources to which he or she has access. He/she shall:

1. Keep his/her exposure as low as practical;
2. Wear assigned personnel monitoring devices in an approved manner;
3. Be familiar with and comply with all sections of this manual applying to his/her work;
4. Be familiar with the nature of his/her area's radiation sources, the extent of their potential risk, and use the proper means of coping with them safely;
5. Monitor his/her area frequently for contamination.
6. Clean up minor spills immediately.
7. Dispose of radioactive waste in an approved manner.
8. See that sources, containers, and the area are properly labeled and posted.
9. Assist in maintaining required records and inventories.
10. Prevent unauthorized persons from having access to radiation sources in his/her area.
11. Protect service personnel, allowing no maintenance or repairs of area facilities or equipment unless approved by the area supervisor and/or DRS.
12. Notify his/her supervisor and DRS of unexpected difficulties.
13. Be prepared to handle accidents or injuries with common sense.
14. Notify and seek the assistance of his/her PI and DRS as soon as possible in emergencies.
15. Take no action that would interfere with the responsibilities of his/her laboratory supervisor.
16. Notify his/her supervisor immediately of any last, stolen, or missing source of radiation.

Appendix B: Recommended Procedures

Appendix B provides recommended procedures for tasks frequently performed in the laboratory. These procedures outline acceptable methods for meeting radiation safety requirements. The procedures are generic in nature, allowing for the diversity of research facilities, on campus.

Contamination Survey Procedures

Surveys are performed to monitor for the presence of contamination. Minimum survey frequencies are specified on the radiation permit. The surveys should be sufficiently extensive to allow confidence that there is no contamination. Common places to check for contamination are: bench tops, tools and equipment, floors, telephones, door handles and drawer pulls, and computer keyboards.

Types of Contamination

Removable contamination can be readily transferred from one surface to another. Removable contamination may present an internal and external hazard because it can be picked up on the skin and ingested. **Fixed contamination** cannot be readily removed and generally does not present a significant hazard unless the material comes loose or is present large enough amounts to be an external hazard.

Types of Surveys

There are two types of survey methods used: 1) a direct (or meter) survey; and 2) a wipe (or smear) survey.

Direct surveys, using a Geiger-Mueller (GM) detector or scintillation probe, can identify gross contamination (total contamination consisting of both fixed and removable contamination) but will detect only certain radioisotopes.

Wipe surveys, using "wipes" such as cotton swabs or filter papers counted on a liquid scintillation counter or gamma counter can identify removable contamination only but will detect most radioisotopes used at the university. Wipe surveys are the most versatile and sensitive method of detecting low-level removable contamination in the laboratory.

Survey Instrumentation

The portable **Geiger-Mueller (GM) survey meter** is best used for P-32, a high-energy beta emitter, and other high-energy beta and gamma emitters, such as Co-60, Zn-65, Cs-137, and U-238. A GM meter can also be used to identify areas heavily contaminated with lower energy beta emitters, such as C-14 or S-35, for which the GM meter has a relatively low efficiency.

GM meters should not be used to survey for I-125 contamination because they detect I-125 only when there are very high levels of contamination.

The portable thin crystal **NaI scintillation survey meter** should be used to locate I-125 contamination and to conduct surveys around low-energy X-ray sources such as X-ray diffractometers and electron microscopes.

The **liquid scintillation counter**, used for counting wipe tests, is the most versatile counting instrument because it has a high counting efficiency for a wide range of radionuclides. Most LSCs provide a printout of sample results that may be used as survey record.

Gamma counters are not portable and are used to count swipes of photon emitters such as Cr-51 or I-125.

How to Perform a Meter Survey

Prior to performing any survey, clean gloves should be worn. This prevents the possibility of personal contamination or cross-contamination.

Perform an instrument check. To check the operation of a survey instrument, do the following:

1. Calibration check:
   Check the calibration label on the instrument and ensure the instrument is within the calibration period. If the calibration due date has passed, contact DRS to have the instrument re-calibrated and find another instrument to use.
   .
2. Battery check:
   Turn the switch on the survey meter to "BATTERY," or flip the battery switch to "ON." The needle on the meter face should move to a position within or beyond the indicated area on the meter face scale. Replace batteries if needed before using the survey meter.

3. Speaker check:
   If there is an audio switch on the survey meter, turn it to "ON." Set the survey meter to a scale of "X1." The survey meter should chirp or click. If the speaker does not function, the survey meter can be used, but the surveyor will need to check the reading on the survey meter face frequently.

4. Background check:
   Go to an area with an expected low background rate. Note the count rate when the survey meter is switched to the "X1" scale. The background rate for a GM meter should be less than 100 counts per minute; the background reading for a NaI meter should be less than 400 counts per minute. If background readings exceed these levels, investigate the area for unknown sources of radiation or detector contamination. Do not use the survey meter if it does not register a background rate.

5. Instrument response check:
   Hold the supplied check source (often a thorium lantern mantle) up to the probe window. Note the counting rate. The survey meter should respond to the check source, thus providing positive indication that the instrument is functioning properly.

Do not cover the probe surface with parafilm or other protective coating. Parafilm and similar materials will shield the low energy betas from C-14, P-33, and S-35 and may prevent the meter from detecting contamination.

Hold the probe window approximately 1 cm from the surface to be surveyed and move the probe over the surface at about 1 cm/second.

Check the most common sites for contamination, such as survey meter handle, soap/towel dispensers, drawer handles, refrigerator/freezer handles, chair edges, writing utensils, survey record books, floors, radio dials, telephone receiver/keypad, microwave oven touch pads/handles, doorknobs, light switches, and non-radioactive trash containers.

Record survey results in a survey log (see Appendix E). Obtain several background readings and record the highest result. Next, complete the survey. If survey results are equivalent to the background, log the result as '≤ BKG'.A surface may be considered contaminated if the result is greater than the background count rate. If contamination is found, record the result and indicate the action taken. Once corrective actions have been taken, perform another survey of the area until the contamination is within the range of highest background results.

How to Perform a Wipe Survey

Prior to performing any survey, clean gloves should be worn. This reduces the likelihood of personal contamination or cross-contamination.

Removable contamination is best identified by a wipe survey, which is performed by rubbing a filter paper (approximately 45 mm in diameter) or cotton swab over the survey area with moderate pressure. The paper or swab may be wetted with ethanol or water to increase the collection efficiency. Usually an area of 100 square centimeters (4 in. X 4 in.) is surveyed. To monitor a larger area, take additional swipes.

If surveying for low-energy beta emitting isotopes such as H-3, C-14, P-33, and S-35, analyze the wipe using liquid scintillation counting.

If surveying for high-energy beta emitters (e.g., P-32), wipe samples may be counted using either liquid scintillation counting or a GM meter.

If monitoring for low-energy gamma emitters (e.g., I-125), wipe samples should be counted with a thin crystal NaI scintillation meter.

The *net sample count rate* is determined by subtracting the background count rate from the gross count rate.

Sample activity is determined by dividing the net sample count rate by the instrument's efficiency for the isotope in question.

Survey results must be documented on a survey log (see Appendix E) or similar form. Results may be reported as *gross count rate, net count rate*, or in units of *activity* (usually *disintegrations per minute*). Ensure that the survey log accurately reflects how results are being reported. Similar to a meter survey, if the result(s) is (are) above the highest background sample the contamination will need to be cleaned. Re-survey to confirm effectiveness of the cleanup of contamination. If the contamination cannot be effectively removed contact DRS.

Personnel Dosimetry

The use and type of personnel dosimetry is determined by the activities and functions the individual performs. By regulation, any person who receives or is likely to receive more than 10 percent of the maximum permissible dose or who enters a high radiation area must be provided with and must wear personnel monitoring devices.

To enroll in dosimetry services, complete a *Dosimetry Request Form* (see Appendix E) and return it to DRS. Upon receipt, DRS personnel initiate the request process with the dosimetry services vendor. The turnaround time is typically one week for a rush order. Therefore, ensure dosimetry requests are made in advance of the need to work with radioactive materials. Note that dosimetry is not issued for individuals working with weak beta-emitting radionuclides such as H-3, C-14, P-33, and S-35.

Whole body dosimeters, or badges, monitor exposure to the whole body and should be worn between the neck and the waist, usually on the front of the body.

Finger ring dosimeters monitor radiation exposure to the hands and fingers. These dosimeters may be worn on any finger and should normally face the palm side of the hand. Finger rings must be worn under gloves to prevent them from becoming contaminated.

Every person with assigned dosimeters must wear the badges and/or ring dosimeters when working with sources of ionizing radiation.

The dosimeter reading is the legal record of an individual's occupational radiation exposure. Therefore, dosimeters shall be worn only by the individual to whom it is assigned, shall not be tampered with or experimentally irradiated, and shall not be used to measure radiation exposure received as a medical patient.

When not being worn, dosimeters must be stored in a location where they will not be exposed to radiation.

Dosimeters are collected monthly or quarterly by DRS personnel and sent to a vendor for processing. Dosimeters must be made available for this exchange to occur.

If a dosimeter is lost, discontinue radiation-related activities and contact DRS. Individuals who have lost a dosimeter must provide information to DRS personnel so that an assessment of their radiation exposure can be performed. DRS will order a replacement dosimeter.

Declaration of Pregnancy

The increased sensitivity of rapidly dividing cells makes the human embryo and fetus particularly susceptible to injury from exposure to ionizing radiation. For this reason, regulations require that exposure to the fetus during the gestation period not exceed 500 millirem (5 mSv). Recommended reading for pregnant female radiation workers is provided in Appendix E.

Any radiation worker who is pregnant or believes that she may be pregnant should contact DRS and review the recommended reading in Appendix E. All inquiries will be confidential. The individual must complete a *Declaration of Pregnancy Form* (see Appendix E). If a written declaration of pregnancy is not submitted, then the worker's dose continues to be controlled under the normal dose limits for radiation workers.

For the type of radiation work performed at the University of Illinois, it is rarely necessary to recommend reassignment or changes to job duties to reduce exposure.

Radioactive Waste Contents Tags Procedure

Radioisotope users are requested to complete waste content tags prior to requesting a pickup of radioactive waste by DRS. Each bag of dry waste or carboy of liquid waste should have a tag attached to it.

Instructions on filling out the tags:

Please print legibly and press hard.

LAB SUPERVISOR: Enter the name of the Radiation Permit Holder.

PERMIT NO.: The Radiation Permit Number.

LOCATION: The building and room number where the radioisotope laboratory is located.

PHONE NO.: The Principal Investigator's office phone number.

DATE SEALED: The date that the container was finally closed after filling.

DRY/LIQUID WASTERADIOACTIVE SHARPS: Indicate whether the waste is in solid, liquid, or sharps disposal container form. If the waste is liquid waste, specify the volume in liters. If the waste is in sharps disposal container form, specify the size of the container on the Cont. # line.

ISOTOPE/ACTIVITY: Indicate the isotope and an estimate of the activity (in mCi). Use separate lines for multiple isotopes. Activity for liquid organic waste must be determined by liquid scintillation counting. Activities given for dry waste should be as accurate as possible. All activities should be decay-corrected if applicable.

BACKGROUND CPM/CONTAINER CPM: The outside of all containers must be surveyed to ensure that container exteriors are free of removable contamination. Moisten a piece of filter paper or a cotton swab with water or alcohol. Wipe an area of approximately 100 square centimeters/per wipe (4 in. X 4 in. /per wipe) along the outside surface of the bag or container. Multiple wipes may be required for larger containers. Record the background cpm as the count rate from the instrument without radioactive materials present. Record the container cpm as the net count rate (gross cpm – background cpm). The container cpm should be less than two times the background count rate. If it is not, either decontaminate the outside of the bag or place the contaminated bag inside a clean bag and re-survey.

If the bag contains H-3, C-14, or S-35, swipes must evaluated by liquid scintillation counting. Wipes for I-125 should be counted with a NaI detector. Wipes for P-32 should be counted on a GM detector. Other radionuclides should be counted using appropriate instrumentation.

SIGNATURE: TAGS MUST BE SIGNED. The signature verifies that all of the information provided is correct.

DATE: Date that tag was completed.

Attach the completed tag to the container.

After waste has been properly prepared, logon to DRS website at:
http://www.drs.illinois.edu/regwaste/rad/index.aspx

Ensure that laboratory records are properly updated.

NOTE:

It is the responsibility of the laboratory personnel to comply with segregation, collection, packaging, and labeling requirements and to secure all wastes for removal from the laboratory. DRS will not handle any package that does not conform to the requirements of Section 8.0, Radioactive Waste" or which, in their opinion, may present a safety hazard to waste-handling personnel or members of the public. Containers/packages of waste that are not properly packaged and labeled must be promptly corrected.

Records Required in the Radiological Laboratory

DRS personnel periodically audit and survey U of I radiological laboratories. The following are expected to be readily available for inspection:

- Laboratory survey records;
- Radioactive material inventory and use records; and,
- Radioactive waste records (solid and liquid). Sewer disposal records can be kept either in the laboratory logs or in DRS database.

If the forms in Appendix E are used, accurately completed, and maintained, no findings of non-compliance should occur during DRS audits of work with radioactive materials. Printouts from automatic counters such as a liquid scintillation counter may be attached and used as a survey record if the sample numbers correspond to survey locations. Records must be maintained by the PI for as long as the radiation permit is active.

DRS personnel perform independent laboratory contamination surveys and audits of laboratory records. The survey and audit results are sent to the PI via campus mail when completed and approved. The following two pages are the forms that Division of Research Safety personnel use to document the results of these surveys and audits.

EXAMPLE

University of Illinois at Urbana-Champaign
Division of Research Safety
Radiation Safety Section
102 EHSB, 101 S. Gregory St., U MC-225

RADIATION SAFETY SURVEY REPORT

Supervisor:	Permit No:
Office:	Performed by:
Survey Date:	

Labs

Building	Room

Survey Results

Location	Direct (cpm)	Swipe DPM (per 100 cm^2)	Exposure (mR\h)

Instruments used in this survey:
Instrument:
Instrument:
Instrument:

EXAMPLE

Illinois

University of Illinois at Urbana-Champaign

Division of Research Safety
Radiation Safety Section
102 EHSB, 101 S. Gregory St., U MC-225

RADIATION SAFETY AUDIT REPORT

Supervisor:	Permit No:
Office:	Performed by:
Lab(s):	Audit Dates:

Status: Satisfactory, Unsatisfactory, Not Applicable, Not Checked

1. Weekly contamination surveys performed when material in use?	
2. Are calibrated instruments available for contamination surveys?	
3. Are inventory, use and waste records up-to-date?	
4. Are there caution signs and employee notices?	
5. Do lab workers wear protective clothing, gloves, eyewear, footwear, etc?	
6. Is absorbent paper used on the benches?	
7. Are training records available for review?	
8. Are isotope areas and articles labeled?	
9. No mouth pipetting!	
10. No eating, drinking and cosmetic use!	
11. No improper food storage!	
12. Are shielding and handling devices in use?	
13. Is the lab locked or attended?	

Survey instruments calibrated (mfr., model, SN):
None calibrated

GENERAL LABORATORY SAFETY AUDIT

4. Is radioactive waste stored properly and labeled?	
15. Are current emergency posting at the entrance	
16. Are Chemical containers labeled properly?	
17. Are gas bottles properly secured?	
18. Are lab door windows unobstructed?	
19. Is housekeeping satisfactory?	
20. Are emergency shower/eyewash stations tested?	
21. Are emergency/eyewash stations accessible?	

Comments:.

Tritium ^{3}H

Radiological half-life, $T_{1/2}$…….12.3 years

Principle emission……..….18.6 keV beta (maximum)

External dose rate (1 cm from a beta point source)……...…….minimal, see below

Annual limit on intake (ALI) by ingestion……...$8x10^{4}$ μCi

Biological monitoring method…….……urine samples

Range in air……4.7 mm

Range in water……..…$6x10^{-3}$ mm

Shielding required……..none

Monitoring method for contamination…….……wipe survey and LSC analysis

Sanitary sewer release concentration limit…..$1x10^{-2}$ μCi/ml

Special considerations

- Tritium compounds do not present an external hazard given the short travel distance of the low energy betas. However, tritium is a primary internal hazard and upon contact tritium compounds can be absorbed through the skin therefore gloves must always be worn. Consider wearing two pair of gloves.

- Place previously opened containers of tritiated water into a fume hood, not a refrigerator. Monitor storage areas where large quantities of H-3 are kept, as certain forms tend to transition and dissipate by becoming airborne and migrating into sources of water/moisture. For example, this "creep" can result in tritium being present in the frost/ice inside a freezer.

- After use of >100 mCi on an open bench or >1000mCi in a fume hood, a bioassay by the Division of Research Safety is required. (prior to using H-3, a baseline bioassay is required)

- Due to its low beta energy, tritium cannot be monitored directly, and therefore regular wipe surveys of the work areas are required.

- ALIs can vary considerably, e.g., DNA precursors such as tritiated thymidine are regarded as more toxic than tritiated water partly because the activity is concentrated in the cell nuclei.

Carbon ^{14}C

Radiological half-life, $T_{1/2}$……5730 years

Principle emission……....156 keV beta (maximum)

External dose rate (@ 1 cm)……1240 R/h, minimal skin penetration, see below

Annual limit on intake (ALI) by ingestion…….……..…….$2x10^3$ μCi

Biological monitoring method…….……breath or urine samples

Range in air……...21.8 cm

Range in water……..…...0.28 mm

Shielding required……1 cm acrylic glass (Plexiglas®; Lucite®)

Monitoring method for contamination…….....……..GM counter

Sanitary sewer release concentration limit……...$9x10^{-5}$ μCi/ml

Special considerations

- Surface contact/exposure to carbon-14 can result in high local doses. However, carbon-14 is a **primarily an internal hazard**. Exposure from external millicurie (or less) sources of carbon-14 ***without contacting*** those materials is low due to the minimal penetration of the outer dead layer of skin. Utilize proper hand/arm protection and avoid inhalation and ingestion.

- Be alert to the chemical properties (e.g., halogenated compounds) of various C-14 compounds and utilize additional hand/arm protection, as required, to prevent potential absorption.

- Use acrylic glass (Plexiglas®; Lucite®) shielding. Do not use lead shielding, which can create Bremsstrahlung radiation.

- Do not generate carbon dioxide which could be inhaled.

Phosphorus ^{32}P

Radiological half-life, $T_{1/2}$…….14.3 days

Principle emission……..…1.71 MeV beta (maximum)

Dose rate (1 cm from a beta point source; isotropic in air, unshielded)…..350 R/h per mCi

Annual limit on intake (ALI) by ingestion…….……..…….$6x10^2$ µCi

Biological monitoring method…….....urine samples

Range in air…….…..6.1 m

Range in water…….……..…..….0.8 cm

Shielding required……1 cm acrylic glass (Plexiglas®; Lucite®)

Monitoring method for contamination……....……..GM counter

Sanitary sewer release concentration limit…….....$9x10^{-5}$ µCi/ml

Special considerations

- Users handling > 10 mCi at a time require a ring (extremity) dosimeter and whole body dosimeter.
- Use acrylic glass (Plexiglas®; Lucite®) shielding. Do not use lead shielding, which can create Bremsstrahlung radiation.
- Do not work over open containers. While the dose rate at the mouth/opening of source vials containing liquid solutions is approximately 20-30% that of an isotropic source in air the dose rate is not attenuated in air. Use proper shielding during liquid transfers and related work.
- When possible utilize tools and handling devices along with proper hand and arm protection to minimize skin exposure.
- Wear eye protection.

Phosphorus ^{33}P

Radiological half-life, $T_{1/2}$…….25.4 days

Principle emission……0.249 MeV beta (maximum)

Dose rate (1 cm from a beta point source)……. 350 R/h per mCi

Annual limit on intake (ALI) by ingestion…….……..…….$6x10^3$ µCi

Biological monitoring method…….....urine samples

Range in air……..….49 cm

Range in water……..…..…0.6 mm

Shielding required……1 cm acrylic glass (Plexiglas®; Lucite®)

Monitoring method for contamination…….....……..GM counter

Sanitary sewer release concentration limit…….....$8x10^{-4}$ µCi/ml

Sulphur ^{35}S

Radiological half-life, $T_{1/2}$…….87.4 days

Principle emission……..…167 keV beta (maximum)

Dose rate (1 cm from a beta point source)…….see below

Annual limit on intake (ALI) by ingestion…….……..…….$6x10^{3}$ µCi

Biological monitoring method…….....urine samples

Range in air…….….26 cm

Range in water…….....0.32 mm

Shielding required……1 cm acrylic glass (Plexiglas®; Lucite®)

Monitoring method for contamination…….....…….. Swipe survey and LSC analysis

Sanitary sewer release concentration limit…..……....$1x10^{-3}$ µCi/ml

Special considerations

- Surveys for gross levels of contamination may be performed using a Geiger counter. However, for a more sensitive analysis particularly in radiologically uncontrolled areas, swipe surveys and LSC analysis should be used.

- Surface contact/exposure to S-35 can result in high local doses. However, sulphur-35 is **primarily an internal hazard**. Exposure from external millicurie (or less) sources of sulphur-35 ***without contacting*** those materials is low due to the minimal penetration of the outer dead layer of skin. Utilize proper hand/arm protection and avoid inhalation and ingestion. Millicurie quantities of S-35 barely penetrate the outer dead layer of skin and do not present a significant external hazard. However, some compounds, such as S-35 methionine, may vaporize upon opening of container. Therefore, open vials in fume hoods to prevent inhalation. Additionally, any heating of S-35 compounds should be done in a fume hood.

Chromium ^{51}Cr

Radiological half-life, $T_{1/2}$…….27.7 days

Principle emissions……..……....0.32 MeV gamma (9.8%), 5 keV X-ray (22%)

Exposure rate (1 cm from 1 mCi point source)……..180 mR/h

Annual limit on intake (ALI) by ingestion…….……..…….$4x10^4$ µCi

Biological monitoring method……...……...whole body count

Half-value layer……3 mm lead

Monitoring method for contamination…….……NaI or other scintillation detector

Sanitary sewer release concentration limit…..……....$5x10^{-3}$ µCi/ml

Technetium ^{99m}Tc

Radiological half-life, $T_{1/2}$…….6.02 hours

Principle emission…….141 MeV gamma (89.1%)

Dose rate (1 cm from a point source)…….720 mrad/h per mCi

Annual limit on intake (ALI) by ingestion…….……..…….8 mCi

Biological monitoring method……...……..urine samples

Half value layer…….…….0.3 mm lead

Monitoring method for contamination……....……..NaI probe

Sanitary sewer release concentration limit…..……....$1x10^{-2}$ μCi/ml

Special considerations

Tc-99m is used in clinical and research diagnostic scanning and imaging.

Drying can cause airborne Tc-99m dust contamination, and rapid boiling can cause airborne Tc-99m aerosol contamination. Expelling Tc-99m solutions through syringe needles and pipette tips can generate airborne aerosols.

Always wear a lab coat and disposable gloves when handling Tc-99m.

A survey meter equipped with a 1" x 1" or a low-energy NaI scintillation probe is preferred for the detection of Tc-99m contamination. Typical counting efficiencies: [1" x 1" NaI probe (39%)] and [low-energy NaI probe (12%-18%)].

Survey meters equipped with a G-M pancake/frisker (15.5 cm^2 surface area) can be used; however, they exhibit very low counting efficiencies (approximately, 1.2%) for detecting low-energy Tc-99m gamma rays. G-M probes are effective only for gross Tc-99m contamination.

Indirect counting using a liquid scintillation counter (LSC), gamma counter, or gas proportional counter (GPC) should be used to detect removable Tc-99m contamination on smears, swabs, or swipes.

Iodine ^{125}I

Radiological half-life, $T_{1/2}$…….60 days

Principle emission…….35 keV gamma (7%), 27-32 keV X-rays (140%)

Exposure rate (1 cm from 1 mCi point source)……..1.4 R/h

Annual limit on intake (ALI) by ingestion…….……..……..40 μCi

Biological monitoring method……...……thyroid scan

Half-value layer……0.02 mm lead

Monitoring method for contamination…….……NaI or other scintillation detector

Sanitary sewer release concentration limit…..……....$2x10^{-5}$ μCi/ml

Special considerations

- Users handling >1 mCi carrier-free iodine on the open bench or >10 mCi carrier-free iodine in a fume hood must report to the Division of Research Safety (DRS) for a thyroid scan within 24-48 hours after use. Prior to work with iodine, a baseline bioassay must be performed.

- Reduce unbound fractions of carrier-free iodine as soon as possible with sodium metabisulfate or thiosulfate.

Iodine ^{131}I

Radiological half-life, $T_{1/2}$……..8.05 days

Principle emission……..364 keV gamma (81.2%)

Exposure rate (1 cm from 1 mCi point source)……..2.0 R/h

Annual limit on intake (ALI) by ingestion…….……..……..30 µCi

Biological monitoring method……...……thyroid scan

Half-value layer…….0.3 cm lead

Monitoring method for contamination…….……NaI or other scintillation detector

Sanitary sewer release concentration limit…..……....$1x10^{-5}$ µCi/ml

Special considerations

- Users handling >1 mCi carrier-free iodine on the open bench or >10 mCi carrier-free iodine in a fume hood must report to DRS for a thyroid scan within 24-48 hours after use. Prior to work with iodine, a baseline bioassay must be performed.

- Reduce unbound fractions of carrier-free iodine as soon as possible with sodium metabisulfate or thiosulfate.

- Emission also includes 606 keV beta that can penetrate the dead layer of skin.

Appendix D: Abbreviations, Conversions, Examples and Formulas

Abbreviations

ALARA – As Low As Reasonably Achievable
Bq – Becquerel
Ci – Curie
cpm – counts per minute
DRS – Division of Research Safety
dpm – disintegration per minute
GM – Geiger-Mueller
Gy – Gray (unit of absorbed dose)
HPLC – High Performance Liquid Chromatography
IEMA – Illinois Emergency Management Agency (formerly Illinois Department of Nuclear Safety (IDNS))
LDPE – low density poly ethylene
LSC – liquid scintillation count or liquid scintillation counter
mCi – millicurie
NaI – sodium iodide
PI – Principal Investigator
μCi – microcurie
R – Roentgen
Rad – radiation absorbed dose
Rem – Roentgen equivalent man
Sv – Sievert

Conversions

2.22×10^6 dpm = 1 microcurie
1000 mirocuries = 1 millicurie
1000 millicuries = 1 Curie
1 Bequerel = 1 disintegration per second (dps)
37 GBq = 1 Ci = 10^9 disintegrations per second (dps)

Formulas and examples

For determination of meter or wipe survey results, use:

$$\text{Activity (dpm)} = \frac{\text{(gross count rate – background count rate)}}{\text{instrument efficiency}}$$

Example: The GM meter response on a benchtop scan was 150 cpm. The background count rate was 40 cpm.

For P-32, the GM efficiency is approximately 50%. What is the amount of activity on the benchtop?

$$\text{Activity (dpm)} = \frac{(150 \text{ cpm} - 40\text{cpm})}{(0.50)} = 220 \text{ dpm}$$

A survey instrument's efficiency can be determined for an individual radionuclide using a known standard (decay-corrected, if necessary) of the radionuclide. The standard is counted in a fixed geometry and the instrument count rate observed. The efficiency is then determined by the formula:

$$\text{Efficiency (\%)} = \frac{(\text{gross count rate} - \text{background count rate}) \times 100}{\text{Activity of standard (dpm)}}$$

Appendix E: Recommended Forms

Form **Page(s)**

UNIVERSITY OF ILLINOIS at URBANA•CHAMPAIGN

RADIATION PERMIT APPLICATION

Division of Research Safety
Radiation Safety Section
(217) 244-4559 –or- (217) 244-7233

101 S. Gregory St., Room 106
Urbana, IL 61801-3070
(217) 333-2755/fax: 244-6594

Applicant Name_____ Department_____

Office Address_____

Phone_____ Email_____@illinois.edu

DRS use only

This permit application is for a (n): ☐ New permit. Permit #_____

☐ Amendment to permit #_____

☐ Renewal of permit #_____

List all labs in which you plan to use or store radioactive materials or radiation-producing equipment and check "Yes" or "No" if these are shared spaces.

Building	*Room*	*Phone*	*Shared Space*
_____	_____	_____	☐ Yes ☐ No
_____	_____	_____	☐ Yes ☐ No
_____	_____	_____	☐ Yes ☐ No

If "YES" has been checked identifying shared space, please list the name of the person(s) who has responsibility for this shared space.

Name	*Location*
_____	_____
_____	_____
_____	_____

List the name(s) of those who will be providing the day-to-day operation of the radiation safety program in the lab.

Name	*Name*
_____	_____
_____	_____

List each radionuclide (of unsealed radioactive material) to be used, the maximum quantity (in millicuries) that you reasonably expect to possess at any one time, and the chemical/physical form of each. Note: Once approved, a permit amendment is necessary to increase a radionuclide quantity.

Nuclide	*Chemical/physical form*	*Maximum quantity (mCi)*

List each sealed radioactive source and other related information, if any are to be used.

Radionuclide	*Manufacturer*	*Activity/date*	*Serial number*

List all radiation-producing equipment to be used, such as X-ray machines, particle accelerators, and other equipment capable of producing ionizing radiation.

Type of equipment	*Model #*	*Types of radiation emitted*

Describe any use of radioactive materials in animals. Provide an estimate of the number of animals to be used, the dosage for each animal, the nature of samples to be taken for measurement, and plans for disposal of animal extractions, excreta, bedding, and carcasses. (Attach additional sheets if necessary)

List all radiation detection instruments available. (Attach additional sheets if necessary)

Type of instrument	*Manufacturer*	*Type of detector (GM, scintillation, ion chamber)*

In general, describe the manipulations and handling of radioactive materials to be used in the laboratory. Include a description of the facilities and equipment that are available at each location where radioactive materials are to be used. Attach drawings describing the facilities, ventilation (fume hoods, filtration,

etc.), storage facilities, (containers, shielding, etc.), waste receptacles, special equipment (remote handling tools, etc.), and protective equipment. (Attach additional sheets if necessary)

Please submit a description of applicable experience in the use of radioactive materials/radiation-generating equipment for each individual listed on page 1. Include where the experience was obtained and the period of experience. (Attach additional sheets if necessary)

Certification

I certify that the information stated herein is true and correct. This application is made under and in conformity with all applicable federal, state, and University regulations. I understand that all individuals working in the areas where radiation hazards may exist, will be informed of: the use and storage of radioactive materials; the health risks associated with radioactive materials; precautions to minimize exposure; the responsibility to promptly report any condition which may cause a violation of the regulations/license or unnecessary exposure to radiation. I further certify that no radioactive material or radiation-producing equipment will be transferred to another person or place inside or outside of the University without the prior consent of the Division of Research Safety. Under no circumstances will radioactive materials be used in humans.

Signature of applicant:_____ Date:_____

For DRS use only Application checklist

☐ Waste receptacle area ☐ Hoods available (if necessary) ☐ Sink for liquid disposal

☐ Check lab egress/exits ☐ Work areas are clearly marked ☐ Radiation detector available

☐ Explain I-number system

Checked by: _____ Date: _____

University of Illinois Dosimetry Request Form

Federal, State and University regulations require that your radiation exposure record contain the following information. Allow 2 weeks for dosimetry to arrive after submitting this form to Radiation Safety. Please complete Part 1 of this form, have your PI complete Part 2, and return the form to:

Division of Research Safety, Radiation Safety Section, MC-225

Part 1……..
(Please print)
Name: _____ UIN: _____
Last first middle

Date of birth: _____ Phone _____

Email: _____

Room/Building where dosimetry will be stored: _____

Please list below, the radioactive material that you will be working with, the **approximate** total activities to be used **per month** and the time handling the materials during a routine week**:**

Isotope(s)	**Quantity (mCi)**	**Handling Time (min/wk.)**
1. _____	**_____**	**_____**
2. _____	**_____**	**_____**
3. _____	**_____**	**_____**
4. _____	**_____**	**_____**
X-ray(s)		
1. _____		**_____**
2. _____		**_____**

Dosimetry desired (*check one or both)*: Whole Body Badge ☐ Extremity Ring ☐

***Check one:* Sex: M ☐ F ☐ Ring size (check *one*): S ☐ M ☐ L ☐ XL ☐**

"I am familiar with the radiation hazards of this project and have read or been instructed in the rules and regulations for the safe use of radioactive materials at the University of Illinois at Urbana-Champaign."

Signed: _____ Date: _____

Part 2……
"I certify that the above individual's work may require him/her to be exposed to ionizing radiation and that he/she has been adequately trained in the procedures necessary to minimize possible hazards."

Principle Investigator: _____

Signature: _____

Date signed: _____ Radiation Permit #_____

For Radiation Safety use only

Badge number assigned:_____ Type:_____ Location:_____
_____ Type:_____ Location:_____

SURVEY LOG

Supervisor: _____ Location: _____

Detector 1: _____ / _____ Date of Calibration: _____
(Model) (Serial #)

Detector 2: _____ / _____ Date of Calibration: _____
(Model) (Serial #)

Survey points and results in cpm per area monitored
(Points should correspond to locations on survey map)

Date & Initials	Detector #	Battery check	Source Check	Back-ground (cpm)	1	2	3	4	5	6	7	8	9	10

Staple RAM receipt tag here.

/DRS/Forms/Survey Log (rev. 0, 2/2003)

Radioisotope Use and Waste Log

Lab Supervisor: _____ Location: _____

Isotope: _____ Vendor: _____

Chemical form: _____ Date received: _____

Original Activity: _____ Assay date: _____ Original volume: _____

Package Contamination Survey Results	
Survey Meter (cpm): **@ 1 meter: _____ @ Surface: _____**	**Smear/Swipe:** **Background** (cpm): _____ **Inner Package** (cpm): _____ *(packing material, vial & container)*
Box Labels/Markings Defaced? Y	**Initials:**

Radioisotope Use Record						**Radioactive Waste Log**				
Date	**Initials**	**Withdrawn**		**Balance**		**Date**	**Check Appropriate Box**		**Activity**	**Sink Disposal Total Volume**
		Activity	**Volume**	**Activity**	**Volume**		**Dry**	**Liquid**		

S:/DRS/Forms/Radioisotope Use & Disposal Log (rev. 0, 2/2003)

University of Illinois
DECLARATION OF PREGNANCY

In accordance with the NRC's regulations at 10 CFR 20.1208, "Dose to an Embryo/Fetus," I am declaring that I am pregnant. I believe I became pregnant in_____ (only month and year need be provided).

I understand the radiation dose to my embryo/fetus during my entire pregnancy will not be allowed to exceed 0.5 rem (5 mSv) (unless that dose has already been exceeded between the time of conception and submitting this letter). I also understand that meeting the lower dose limit may require a change in job or job responsibilities during my pregnancy.

I have been given the opportunity to read USNRC Regulatory Guide 8.13 "Instruction Concerning Prenatal Radiation Exposure" and IDNS Rules and Regulations, Parts 340.280 and 340.530.

_____ _____ _____

(Your Name Printed) (Your Signature) (Date)

_____ _____

(Work location where dosimetry will be kept) (Phone number)

_____ _____/_____/_____

(UIN) (Date of birth)

Disclosure Statement

You must provide your name, University ID Number (UIN), and date of birth for the University of Illinois to process a dosimetry request. Federal and State law require the University to maintain this information and provide your exposure history upon your authorization. The University will not disclose a recipient's personal information without the consent of the recipient to anyone outside the University except as mandated by law.

Complete and return this form via campus mail to:

Radiation Safety, MC-225, 101 S. Gregory St., Urbana, IL,

Division of Research Safety use only:
Fetal badge number assigned: _____ Location: _____ Date issued: _____

S:/DRS/Forms/Declaration of Pregnancy Form (rev. 2, 09/2010)

Recommended Reading for Pregnant Female Radiation Workers

Regulatory Guide 8.13 - Instruction Concerning Prenatal Radiation Exposure

Revision 3, June 1999

A. INTRODUCTION

The Code of Federal Regulations in 10 CFR Part 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations," in Section 19.12, "Instructions to Workers," requires instruction in "the health protection problems associated with exposure to radiation and/or radioactive material, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed." The instructions must be "commensurate with potential radiological health protection problems present in the work place."

The Nuclear Regulatory Commission's (NRC's) regulations on radiation protection are specified in 10 CFR Part 20, "Standards for Protection Against Radiation"; and Section 20.1208, "Dose to an Embryo/Fetus," requires licensees to "ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv)." Section 20.1208 also requires licensees to "make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman." A declared pregnant woman is defined as a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

This regulatory guide is intended to provide information to pregnant women, and other personnel, to help them make decisions regarding radiation exposure during pregnancy. This Regulatory Guide 8.13 supplements Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure" (Ref. 1), which contains a broad discussion of the risks from exposure to ionizing radiation.

Other sections of the NRC's regulations also specify requirements for monitoring external and internal occupational dose to a declared pregnant woman. Licensees are required to monitor the occupational dose to a declared pregnant woman, using an individual monitoring device, if it is likely that the declared pregnant woman will receive, from external sources, a deep dose equivalent in excess of 0.1 rem (1 mSv). The licensee must maintain records of dose to an embryo/fetus if monitoring was required, and the records of dose to the embryo/fetus must be kept with the records of dose to the declared pregnant woman. The declaration of pregnancy must be kept on file, but may be maintained separately from the dose records. The licensee must retain the required form or record until the Commission terminates each pertinent license requiring the record.

B. DISCUSSION

As discussed in Regulatory Guide 8.29 (Ref. 1), exposure to any level of radiation is assumed to carry with it a certain amount of risk. In the absence of scientific certainty regarding the relationship between low dose exposure and health effects, and as a conservative assumption for radiation protection purposes, the scientific community generally assumes that any exposure to ionizing radiation may cause undesirable biological effects and that the

likelihood of these effects increases as the dose increases. At the occupational dose limit for the whole body of 5 rem (50 mSv) per year, the risk is believed to be very low.

The magnitude of risk of childhood cancer following in utero exposure is uncertain in that both negative and positive studies have been reported. The data from these studies "are consistent with a lifetime cancer risk resulting from exposure during gestation which is two to three times that for the adult" (NCRP Report No. 116, Ref. 2). The NRC has reviewed the available scientific literature and has concluded that the 0.5 rem (5 mSv) limit specified in 10 CFR 20.1208 provides an adequate margin of protection for the embryo/fetus. This dose limit reflects the desire to limit the total lifetime risk of leukemia and other cancers associated with radiation exposure during pregnancy.

In order for a pregnant worker to take advantage of the lower exposure limit and dose monitoring provisions specified in 10 CFR Part 20, the woman must declare her pregnancy in writing to the licensee. A separate written declaration should be submitted for each pregnancy.

C. REGULATORY POSITION

1. Who Should Receive Instruction

   Female workers who require training under 10 CFR 19.12 should be provided with the information contained in this guide. In addition to the information contained in Regulatory Guide 8.29 (Ref. 1), this information may be included as part of the training required under 10 CFR 19.12.

2. Providing Instruction

   The occupational worker may be given a copy of this guide with its Appendix, an explanation of the contents of the guide, and an opportunity to ask questions and request additional information. The information in this guide and Appendix should also be provided to any worker or supervisor who may be affected by a declaration of pregnancy or who may have to take some action in response to such a declaration.

   Classroom instruction may supplement the written information. If the licensee provides classroom instruction, the instructor should have some knowledge of the biological effects of radiation to be able to answer questions that may go beyond the information provided in this guide. Videotaped presentations may be used for classroom instruction. Regardless of whether the licensee provides classroom training, the licensee should give workers the opportunity to ask questions about information contained in this Regulatory Guide 8.13. The licensee may take credit for instruction that the worker has received within the past year at other licensed facilities or in other courses or training.

3. Licensee's Policy on Declared Pregnant Women

   The instruction provided should describe the licensee's specific policy on declared pregnant women, including how those policies may affect a woman's work situation.

   In particular, the instruction should include a description of the licensee's policies, if any, that may affect the declared pregnant woman's work situation after she has filed a written declaration of pregnancy consistent with 10 CFR 20.1208.

   The instruction should also identify who to contact for additional information as well as identify who should receive the written declaration of pregnancy. The recipient of the

woman's declaration may be identified by name (e.g., John Smith), position (e.g., immediate supervisor, the radiation safety officer), or department (e.g., the personnel department).

4. Duration of Lower Dose Limits for the Embryo/Fetus

   The lower dose limit for the embryo/fetus should remain in effect until the woman withdraws the declaration in writing or the woman is no longer pregnant. If a declaration of pregnancy is withdrawn, the dose limit for the embryo/fetus would apply only to the time from the estimated date of conception until the time the declaration is withdrawn. If the declaration is not withdrawn, the written declaration may be considered expired one year after submission.

5. Substantial Variations Above a Uniform Monthly Dose Rate

   According to 10 CFR 20.1208(b), "The licensee shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in paragraph (a) of this section," that is, 0.5 rem (5 mSv) to the embryo/fetus. The National Council on Radiation Protection and Measurements (NCRP) recommends a monthly equivalent dose limit of 0.05 rem (0.5 mSv) to the embryo/fetus once the pregnancy is known (Ref. 2). In view of the NCRP recommendation, any monthly dose of less than 0.1 rem (1 mSv) may be considered as not a substantial variation above a uniform monthly dose rate and as such will not require licensee justification. However, a monthly dose greater than 0.1 rem (1 mSv) should be justified by the licensee.

REFERENCES

1. USNRC, "Instruction Concerning Risks from Occupational Radiation Exposure," Regulatory Guide 8.29, Revision 1, February 1996.

2. National Council on Radiation Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, Bethesda, MD, 1993.

QUESTIONS AND ANSWERS CONCERNING PRENATAL RADIATION EXPOSURE

1. Why am I receiving this information?

The NRC's regulations (in 10 CFR 19.12, "Instructions to Workers") require that licensees instruct individuals working with licensed radioactive materials in radiation protection as appropriate for the situation. The instruction below describes information that occupational workers and their supervisors should know about the radiation exposure of the embryo/fetus of pregnant women. The regulations allow a pregnant woman to decide

whether she wants to formally declare her pregnancy to take advantage of lower dose limits for the embryo/fetus. This instruction provides information to help women make an informed decision whether to declare a pregnancy.

2. **If I become pregnant, am I required to declare my pregnancy?**

   No. The choice whether to declare your pregnancy is completely voluntary. If you choose to declare your pregnancy, you must do so in writing and a lower radiation dose limit will apply to your embryo/fetus. If you choose not to declare your pregnancy, you and your embryo/fetus will continue to be subject to the same radiation dose limits that apply to other occupational workers.

3. **If I declare my pregnancy in writing, what happens?**

   If you choose to declare your pregnancy in writing, the licensee must take measures to limit the dose to your embryo/fetus to 0.5 rem (5 mSv) during the entire pregnancy. This is one-tenth of the dose that an occupational worker may receive in a year. If you have already received a dose exceeding 0.5 rem (5 mSv) in the period between conception and the declaration of your pregnancy, an additional dose of 0.05 rem (0.5 mSv) is allowed during the remainder of the pregnancy. In addition, 10 CFR 20.1208, "Dose to an Embryo/Fetus," requires licensees to make efforts to avoid substantial variation above a uniform monthly dose rate so that all the 0.5 rem (5 mSv) allowed dose does not occur in a short period during the pregnancy.

   This may mean that, if you declare your pregnancy, the licensee may not permit you to do some of your normal job functions if those functions would have allowed you to receive more than 0.5 rem, and you may not be able to have some emergency response responsibilities.

4. **Why do the regulations have a lower dose limit for the embryo/fetus of a declared pregnant woman than for a pregnant worker who has not declared?**

   A lower dose limit for the embryo/fetus of a declared pregnant woman is based on a consideration of greater sensitivity to radiation of the embryo/fetus and the involuntary nature of the exposure. Several scientific advisory groups have recommended (References 1 and 2) that the dose to the embryo/fetus be limited to a fraction of the occupational dose limit.

5. **What are the potentially harmful effects of radiation exposure to my embryo/fetus?**

   The occurrence and severity of health effects caused by ionizing radiation are dependent upon the type and total dose of radiation received, as well as the time period over which the exposure was received. See Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Exposure" (Ref. 3), for more information. The main concern is embryo/fetal susceptibility to the harmful effects of radiation such as cancer.

6. **Are there any risks of genetic defects?**

   Although radiation injury has been induced experimentally in rodents and insects, and in the experiments was transmitted and became manifest as hereditary disorders in their offspring, radiation has not been identified as a cause of such effect in humans. Therefore, the risk of genetic effects attributable to radiation exposure is speculative. For example, no genetic effects have been documented in any of the Japanese atomic bomb survivors, their children, or their grandchildren.

7. What if I decide that I do not want any radiation exposure at all during my pregnancy?

You may ask your employer for a job that does not involve any exposure at all to occupational radiation dose, but your employer is not obligated to provide you with a job involving no radiation exposure. Even if you receive no occupational exposure at all, your embryo/fetus will receive some radiation dose (on average 75 mrem (0.75 mSv)) during your pregnancy from natural background radiation.

The NRC has reviewed the available scientific literature and concluded that the 0.5 rem (5 mSv) limit provides an adequate margin of protection for the embryo/fetus. This dose limit reflects the desire to limit the total lifetime risk of leukemia and other cancers. If this dose limit is exceeded, the total lifetime risk of cancer to the embryo/fetus may increase incrementally. However, the decision on what level of risk to accept is yours. More detailed information on potential risk to the embryo/fetus from radiation exposure can be found in References 2-10.

8. What effect will formally declaring my pregnancy have on my job status?

Only the licensee can tell you what effect a written declaration of pregnancy will have on your job status. As part of your radiation safety training, the licensee should tell you the company's policies with respect to the job status of declared pregnant women. In addition, before you declare your pregnancy, you may want to talk to your supervisor or your radiation safety officer and ask what a declaration of pregnancy would mean specifically for you and your job status.

In many cases you can continue in your present job with no change and still meet the dose limit for the embryo/fetus. For example, most commercial power reactor workers (approximately 93%) receive, in 12 months, occupational radiation doses that are less than 0.5 rem (5 mSv) (Ref. 11). The licensee may also consider the likelihood of increased radiation exposures from accidents and abnormal events before making a decision to allow you to continue in your present job.

If your current work might cause the dose to your embryo/fetus to exceed 0.5 rem (5 mSv), the licensee has various options. It is possible that the licensee can and will make a reasonable accommodation that will allow you to continue performing your current job, for example, by having another qualified employee do a small part of the job that accounts for some of your radiation exposure.

9. What information must I provide in my written declaration of pregnancy?

You should provide, in writing, your name, a declaration that you are pregnant, the estimated date of conception (only the month and year need be given), and the date that you give the letter to the licensee.

10. To declare my pregnancy, do I have to have documented medical proof that I am pregnant?

NRC regulations do not require that you provide medical proof of your pregnancy. However, NRC regulations do not preclude the licensee from requesting medical documentation of your pregnancy, especially if a change in your duties is necessary in order to comply with the 0.5 rem (5 mSv) dose limit.

11. Can I tell the licensee orally rather than in writing that I am pregnant?

No. The regulations require that the declaration must be in writing.

12. If I have not declared my pregnancy in writing, but the licensee suspects that I am pregnant, do the lower dose limits apply?

No. The lower dose limits for pregnant women apply only if you have declared your pregnancy in writing. The United States Supreme Court has ruled (in *United Automobile Workers International Union v. Johnson Controls, Inc*., 1991) that "Decisions about the welfare of future children must be left to the parents who conceive, bear, support, and raise them rather than to the employers who hire those parents" (Reference 7). The Supreme Court also ruled that your employer may not restrict you from a specific job "because of concerns about the next generation." Thus, the lower limits apply only if you choose to declare your pregnancy in writing.

13. If I am planning to become pregnant but am not yet pregnant and I inform the licensee of that in writing, do the lower dose limits apply?

No. The requirement for lower limits applies only if you declare in writing that you are already pregnant.

14. What if I have a miscarriage or find out that I am not pregnant?

If you have declared your pregnancy in writing, you should promptly inform the licensee in writing that you are no longer pregnant. However, if you have not formally declared your pregnancy in writing, you need not inform the licensee of your nonpregnant status.

15. How long is the lower dose limit in effect?

The dose to the embryo/fetus must be limited until you withdraw your declaration in writing or you inform the licensee in writing that you are no longer pregnant. If the declaration is not withdrawn, the written declaration may be considered expired one year after submission.

16. If I have declared my pregnancy in writing, can I revoke my declaration of pregnancy even if I am still pregnant?

Yes, you may. The choice is entirely yours. If you revoke your declaration of pregnancy, the lower dose limit for the embryo/fetus no longer applies.

17. What if I work under contract at a licensed facility?

The regulations state that you should formally declare your pregnancy to the licensee in writing. The licensee has the responsibility to limit the dose to the embryo/fetus.

18. Where can I get additional information?

The references to this Appendix contain helpful information, especially Reference 3, NRC's Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure," for general information on radiation risks. The licensee should be able to give this document to you.

For information on legal aspects, see Reference 7, "The Rock and the Hard Place: Employer Liability to Fertile or Pregnant Employees and Their Unborn Children--What Can the Employer Do?" which is an article in the journal *Radiation Protection Management*.

You may telephone the NRC Headquarters at (301) 415-7000. Legal questions should be directed to the Office of the General Counsel, and technical questions should be directed to the Division of Industrial and Medical Nuclear Safety.

You may also telephone the NRC Regional Offices at the following numbers: Region I, (610) 337-5000; Region II, (404) 562-4400; Region III, (630) 829-9500; and Region IV, (817) 860-8100. Legal questions should be directed to the Regional Counsel, and technical questions should be directed to the Division of Nuclear Materials Safety.

REFERENCES FOR QUESTIONS

1. National Council on Radiation Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116, Bethesda, MD, 1993.
2. International Commission on Radiological Protection, *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, Ann. ICRP 21: No. 1-3, Pergamon Press, Oxford, UK, 1991.
3. USNRC, "Instruction Concerning Risks from Occupational Radiation Exposure," Regulatory Guide 8.29, Revision 1, February 1996.(1) (Electronically available at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/)
4. Committee on the Biological Effects of Ionizing Radiations, National Research Council, *Health Effects of Exposure to Low Levels of Ionizing Radiation* (BEIR V), National Academy Press, Washington, DC, 1990.
5. United Nations Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation*, United Nations, New York, 1993.
6. R. Doll and R. Wakeford, "Risk of Childhood Cancer from Fetal Irradiation," *The British Journal of Radiology*, 70, 130-139, 1997.
7. David Wiedis, Donald E. Jose, and Timm O. Phoebe, "The Rock and the Hard Place: Employer Liability to Fertile or Pregnant Employees and Their Unborn Children--What Can the Employer Do?" *Radiation Protection Management*, *11*, 41-49, January/February 1994.
8. National Council on Radiation Protection and Measurements, *Considerations Regarding the Unintended Radiation Exposure of the Embryo, Fetus, or Nursing Child*, NCRP Commentary No. 9, Bethesda, MD, 1994.
9. National Council on Radiation Protection and Measurements, *Risk Estimates for Radiation Protection*, NCRP Report No. 115, Bethesda, MD, 1993.
10. National Radiological Protection Board, *Advice on Exposure to Ionising Radiation During Pregnancy*, National Radiological Protection Board, Chilton, Didcot, UK, 1998.
11. M.L. Thomas and D. Hagemeyer, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities, 1996," Twenty-Ninth Annual Report, NUREG-0713, Vol. 18, USNRC, 1998.(2)

ILLINOIS ADMINISTRATIVE CODE
TITLE 32: ENERGY
CHAPTER II: DEPARTMENT OF NUCLEAR SAFETY
SUBCHAPTER b: RADIATION PROTECTION
PART 340, STANDARDS FOR PROTECTION AGAINST RADIATION

Section 340.280 Dose to an Embryo/Fetus

a) Except as otherwise provided in subsections (d) and (e) below, the licensee or registrant shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 5 mSv (0.5 rem). (For recordkeeping requirements, see Section 340.1160(d).)

b) The dose to an embryo/fetus shall be taken as the sum of:

1) The deep dose equivalent to the declared pregnant woman during the entire pregnancy; and

2) The dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman during the entire pregnancy.

c) The licensee or registrant shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit in subsection (a) above.

AGENCY NOTE: The National Council on Radiation Protection and Measurements report entitled "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP 91, published June 1, 1987, recommends that no more than 0.5 mSv (0.05 rem) of the allowed dose to the embryo/fetus be received during any one month during a declared pregnancy.

d) If the declared pregnant woman has not notified the licensee or registrant of the estimated date of conception, the licensee or registrant shall ensure that the dose to an embryo/fetus, as specified in subsection (b) above, due to occupational exposure of the declared pregnant woman does not exceed 0.5 mSv (0.05 rem) per month, during the remainder of the pregnancy. If after initially declaring her pregnancy, a declared pregnant woman advises the licensee or registrant of the estimated date of conception, the dose limits specified in subsections (a) and (e) of this Section shall apply.

AGENCY NOTE: The Department encourages licensees and registrants to explain to declared pregnant workers that providing an estimated date of conception will enable the licensee or registrant to more accurately assess the radiation dose to the embryo/fetus and assist the licensee or registrant in determining appropriate precautions to be taken for the remainder of the pregnancy.

e) If by the time the woman informs the licensee or registrant of the estimated date of conception the dose to the embryo/fetus has exceeded 4.5 mSv (0.45 rem), the licensee or registrant shall be deemed to be in compliance with subsection (a) above if the additional

dose to the embryo/fetus as specified in subsection (b) above does not exceed 0.5 mSv (0.05 rem) during the remainder of the pregnancy.

Section 340.530 Location of Individual Monitoring Devices

Each licensee or registrant shall ensure that individuals who are required to monitor occupational doses in accordance with Section 340.520(a) wear individual monitoring devices as follows:

a) An individual monitoring device used for monitoring the dose to the whole body shall be worn at the unshielded location of the whole body likely to receive the highest exposure. When a protective apron is worn, the location of the individual monitoring device is typically at the neck (collar).

b) An individual monitoring device used for monitoring the dose to an embryo/fetus of a declared pregnant woman, pursuant to Section 340.280(a), shall be located at the waist under any protective apron being worn by the woman.

c) An individual monitoring device used for monitoring the eye dose equivalent, to demonstrate compliance with Section 340.210(a)(2)(A), shall be located at the neck (collar), outside any protective apron being worn by the monitored individual, or at an unshielded location closer to the eye.

d) An individual monitoring device used for monitoring the dose to the extremities, to demonstrate compliance with Section 340.210(a) (2)(B), shall be worn on the extremity likely to receive the highest exposure. Each individual monitoring device shall be oriented to measure the highest dose to the extremity being monitored.

Appendix F: Glossary

"**Absorbed dose**" means the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the gray (Gy) and the rad.

"**Accelerator**" (particle accelerator) means any machine capable of accelerating electrons, protons, deuterons or other charged particles in a vacuum and of discharging the resultant particulate or other radiation into a medium at energies usually in excess of 1 million electron volts (MeV).

"**Accelerator-produced material**" means any material made radioactive by a particle accelerator.

"**Activity**" means the rate of disintegration (transformation) or decay of radioactive material. The units of activity are the becquerel (Bq) and the curie (Ci).

"**Adult**" means an individual 18 or more years of age.

"**Agreement State**" means any state with which the U.S. Nuclear Regulatory Commission or the U.S. Atomic Energy Commission has entered into an effective agreement under subsection 274b of the Atomic Energy Act of 1954, as amended.

"**Airborne radioactive material**" means any radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors or gases.

"**Airborne radioactivity area**" means any room, enclosure, or operating area in which airborne radioactive material, composed wholly or partly of licensed material, exists in concentrations

(1) In excess of the derived air concentrations (DAC's) specified in Appendix B to 10 CFR 20.1001 - 20.2401, effective January 1, 1998, exclusive of subsequent amendments or editions; or

(2) To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

"**ALI** or **Annual Limit on Intake**" means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year.

"**As Low As Is Reasonably Achievable**" (ALARA) means making every reasonable effort to maintain exposures to radiation as far below the dose limits in 32 Ill. Adm. Code: Chapter II, Subchapters b and d as is practical, consistent with the purpose for which the licensed or registered activity is undertaken, and taking into account the state of technology, the economics of improvements in relation to the state of technology, the economics of improvements in relation to benefits to the public health and safety and other societal and

socioeconomic considerations, and in relation to utilization of nuclear energy and licensed or registered sources of radiation in the public interest.

"**Background radiation**" means radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. Background radiation does not include radiation from radioactive materials regulated by the Illinois Department of Nuclear Safety.

"**Becquerel**" (Bq) means the SI unit of activity. One becquerel (Bq) is equal to 1 disintegration (transformation) per second (dps or tps).

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

"**Byproduct material**" means

(1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident or to the process of producing or utilizing special nuclear material; and
(2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from underground solution extraction processes but not including underground ore bodies depleted by such solution extraction processes.

"**Calendar quarter**" means not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year shall begin in January and subsequent calendar quarters shall be so arranged such that no day is included in more than one calendar quarter and no day in any one year is omitted from inclusion within a calendar quarter. No licensee or registrant shall change the method observed by him for determining calendar quarters except at the beginning of a year.

"**Calibration**" means the determination of

(1) the response or reading of an instrument relative to a series of known radiation values over the range of the instrument; or
(2) the strength of a source of radiation relative to a standard.

"**CFR**" means Code of Federal Regulations.

"**Chelating Agent**" means amine polycarboxylic acids (e.g., EDTA, DTPA), hydroxy-carboxylic acids and polycarboxylic acids (e.g., citric acid, carbolic acid and glucinic acid).

"**Committed dose equivalent**" (H[T,50]) means the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

"**Committed effective dose equivalent**" (H[E,50]) means the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to each of these organs or tissues (H[E,50] = SUM w[T]H[T,50]).

"**Critical Organ**" means that organ (or tissue) in which the dose equivalent would be the most significant due to a combination of the organ's radiosensitivity and a particular dose pattern throughout the body.

"**Curie**" means a unit of quantity of radioactivity. One curie (Ci) is that quantity of radioactive material which decays at the rate of 3.7×10^{10} disintegrations (transformations) per second (dps or tps).

"**Declared pregnant woman**" means any woman who has voluntarily informed her employer, in writing, of her pregnancy.

"**Deep dose equivalent**" (H[d]) means the dose equivalent at a tissue depth of 1 centimeter (1,000 milligrams per square centimeter) from external whole-body exposure.

"**Depleted uranium**" means the source material uranium in which the isotope uranium-235 is less than 0.711 weight percent of the total uranium present. Depleted uranium does not include special nuclear material.

"**Dose**" (radiation dose) means either absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, total organ dose equivalent, or total effective dose equivalent.

"**Dose equivalent**" (H[T]) means the product of the absorbed dose in tissue, quality factor and all other necessary modifying factors (e.g., a distribution factor for non-uniform deposition) at the location of interest. The units of dose equivalent are the sievert (Sv) and the rem.

"**Dose limits**" (limits) means the permissible upper bounds of radiation doses established by, or in accordance with, 32 Ill. Adm. Code: Chapter II, Subchapters b and d.

"**Dose rate**" means the dose per unit of time, such as rem per minute (rem/min) and millirem per hour (mrem/hr.). See also "Exposure rate"

"**Effective dose equivalent**" (H[E]) means the sum of the products of the dose equivalent to each organ or tissue (H[T]) and the weighting factor (W[T]) applicable to each of the body organs or tissues that are irradiated (H[E] = SUM w[T]H[T]).

"**Embryo/fetus**" means the developing human organism from conception until the time of birth.

"**Exposure**" means

(1) the quotient of dQ divided by dm where "dQ" is the absolute value of the total charge of the ions of one sign produced in air when all the electrons (negatrons and positrons) liberated by photons in a volume element of air having mass "dm" are completely stopped in air; or

(2) irradiation by ionizing radiation or radioactive material. NOTE: The context makes clear which is the appropriate definition.

"**Exposure rate**" means the exposure per unit of time, such as roentgen per minute (R/min) and milli-roentgen per hour (mR/hr.). See also "Dose rate".

"**External dose**" means that portion of the dose equivalent received from any source of radiation outside the body.

"**Extremity**" means a hand, elbow, arm below the elbow, foot, knee and leg below the knee.

"**Eye dose equivalent**" or "lens dose equivalent" means the external dose equivalent to the lens of the eye at a tissue depth of 0.3 centimeter (300 milligrams per square centimeter).

"**Gray**" (Gy) is the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 joule per kilogram (J/kg) (1 Gy = 100 rad).

"**Half-life, biological**" is the time required for the body to eliminate one-half of an administered dosage of any substance by regular process of elimination.

"**Half-life, effective**" is the time required for a radioactive element in a body to decrease to one half of its original value as a result of the combined action of radioactive decay and biological elimination. The effective half-life is always shorter than either the radiological or biological half-life.

"**Half-life, radiological**" is the time required for the amount of a particular radionuclide to decrease to one half of its original value.

"**Healing Arts**" means the art or science or group of arts or sciences dealing with the prevention and cure or alleviation of human ailments, diseases or infirmities, and has the same meaning as "medicine" when the latter term is used in its comprehensive sense.

"**High radiation area**" means any area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 1 mSv (0.1 rem) in 1 hour at 30 centimeters from any source of radiation or from any surface that the radiation penetrates.

"**Human use**" means the internal or external administration of radiation or radioactive materials to human beings.

"**Individual**" means any human being.
"**Individual monitoring**" means the assessment of

(1) Dose equivalent by the use of individual monitoring devices or by the use of survey data; or
(2) Committed effective dose equivalent by bioassay or by determination of the time-weighted air concentrations to which an individual has been exposed (i.e., DAC-hours). (For the definition of DAC-hours, see 32 Ill. Adm. Code 340.30.)

"**Individual monitoring devices**" (personnel dosimeter or dosimeter) means devices designed to be worn by a single individual for the assessment of dose equivalent. Examples of individual monitoring devices are film badges, thermoluminescence dosimeters (TLDs), optically stimulated luminescence dosimeters (OSLs), pocket ionization chambers, personal air sampling devices and electronic dosimeters (e.g., silicon diode dosimeters).

"**Inspection**" means an official examination or observation including, but not limited to, tests, surveys and monitoring to determine compliance with rules, regulations, orders, requirements and conditions of the Illinois Department of Nuclear Safety.

"Ionizing Radiation" (see "Radiation")

"**Isotope**" is a different form of the same chemical element distinguished by having a different number of neutrons (but the same number of protons) in the nucleus. Nearly identical chemical properties exist between isotopes of a particular element. Isotope should not be used as a synonym for nuclide. The terms "*radioisotope*" and "*radionuclide*", are commonly used to identify radioactive isotopes and radioactive nuclides, respectively.

"**License**" means any license issued by the Illinois Emergency Management Agency in accordance with 32 Ill. Adm. Code: Chapter II, Subchapters b and d.

"**Licensed material**" means radioactive material received, possessed, used, transferred or disposed of under a general or specific license issued by the Illinois Department of Nuclear Safety.

"LSC or **Liquid scintillation counting"** is a standard laboratory method for measuring radiation from low energy beta-emitting nuclides. Samples are dissolved or suspended in a "cocktail" containing an aromatic solvent and small amounts of other additives known as fluors. Beta particles emitted from the sample transfer energy to the solvent molecules, which in turn transfer their energy to the fluors; the excited fluor molecules dissipate the energy by emitting light. In this way, each beta emission (ideally) results in a pulse of light. The samples are placed in small transparent or translucent (often glass or plastic) vials that are loaded into an instrument known as a liquid scintillation counter.

"**Lost or missing source of radiation**" means any licensed or registered source of radiation whose location is unknown. This definition includes, but is not limited to, radioactive

material that has been shipped but has not reached its planned destination and whose location cannot be readily traced in the transportation system.

"**Member of the public**" means any individual, except an individual who is performing assigned duties for the licensee or registrant involving exposure to sources of radiation.

"**Minor**" means an individual less than 18 years of age.

"**Monitoring**" (radiation monitoring or radiation protection monitoring) means the measurement of radiation, radioactive material concentrations, surface area activities or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

"**NORM**" **or** "**NARM**" means any naturally occurring or accelerator-produced radioactive material. It does not include byproduct, source or special nuclear material.

"**Natural radioactivity**" means radioactivity of naturally occurring nuclides.

"**Non-ionizing radiation**" means radiation that does not produce ionization. Examples are sound, radio waves, visible, infrared, and ultraviolet light.

"**Occupational dose**" means the dose received by an individual in the course of employment in which the individual's assigned duties for the licensee or registrant involve exposure to sources of radiation. Occupational dose does not include dose received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released as authorized by the Illinois Department of Nuclear Safety, from voluntary participation in medical research programs, or as a member of the public.

"**Package**" means the packaging, together with its radioactive contents, as presented for transport.

"**Person**" means any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, agency, political subdivision of this State, any other State or political subdivision or agency thereof, and any legal successor, representative, agent, or agency of the foregoing, other than the U.S. Nuclear Regulatory Commission, or any successor thereto, and other than federal government agencies licensed by the U.S. Nuclear Regulatory Commission, or any successor thereto. "Person" also includes a federal entity (and its contractors) if the federal entity agrees to be regulated by the State or as otherwise allowed under federal law.

"**Personnel monitoring equipment**" (see "Individual monitoring devices").

"**Public dose**" means the dose received by a member of the public from sources of radiation from licensed or registered operations. Public dose does not include occupational dose, or dose received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released as authorized by the Illinois Department of Nuclear Safety, or from voluntary participation in medical research programs.

"**Rad**" is a unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs per gram or 0.01 joule per kilogram (J/kg) (0.01 Gy).

"**Radiation**" (ionizing radiation) means gamma rays and X-rays, alpha and beta particles, high-speed electrons, neutrons, protons, and other nuclear particles, or electromagnetic radiations capable of producing ions directly or indirectly in their passage through matter; but does not include sound or radio waves, or visible, infrared or ultraviolet light.

"**Radiation area**" means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.05 mSv (0.005 rem) in 1 hour at 30 centimeters from the source of radiation or from any surface that the radiation penetrates.

"**Radiation emergency**" means the uncontrolled release of radioactive material from a radiation installation which poses a potential threat to the public health, welfare and safety.

"**Radiation Installation**" is any location or facility where radiation machines are used or where radioactive material is produced, transported, stored, disposed or used for any purpose, except where such radioactive materials or facility are subject to regulation by the Nuclear Regulatory Commission.

"**Radiation machine**" means any device that produces radiation when in use, except those which produce radiation only from radioactive materials.

"**Radiation safety officer**" means an individual who has the knowledge and responsibility to apply appropriate radiation protection regulations and has been assigned such responsibility by the licensee or registrant.

"**Radioactive material**" means any solid, liquid or gaseous substance, which emits radiation spontaneously.

"**Radioactivity**" means the disintegration (transformation) of unstable atomic nuclei by the emission of radiation.

"**Rem**" means the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rem is equal to the absorbed dose in rad multiplied by the quality factor (1 rem = 0.01 Sv).

"**Restricted area**" means any area to which access is limited by the licensee or registrant for purposes of protecting individuals against undue risks from exposure to sources of radiation. Restricted area shall not include areas used for residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

"**Roentgen**" means the special unit of exposure. One roentgen (R) equals 2.58 x 10^{-4} coulombs per kilogram (C/kg). (See "Exposure" and Section 310.140 of this Part.)
"Scintillation counter" measures ionizing radiation. The counter consists of a transparent crystal (such as NaI or Ge), usually phosphor, plastic, or organic liquid (see liquid scintillation counting) that fluoresces when struck by ionizing radiation. A sensitive photomultiplier tube (PMT) measures the light from the crystal. The PMT is attached to an electronic amplifier and other electronic equipment to count and possibly quantify the amplitude of the signals produced by the photomultiplier.

"**Sealed source**" means any device containing radioactive material to be used as a source of radiation which has been constructed in such a manner as to prevent the escape of any radioactive material.

"**Shallow dose equivalent**" (H[S]), which applies to the external exposure of the skin or an extremity, means the dose equivalent at a tissue depth of 0.007 centimeter (7 milligrams per square centimeter) averaged over an area of 1 square centimeter.

"**SI**" means the abbreviation for the International System of Units.

"**Sievert**" (Sv) means the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sievert is equal to the absorbed dose in gray multiplied by the quality factor (1 Sv = 100 rem).

"**Source of radiation**" means any radioactive material or any device or equipment emitting, or capable of producing, radiation.

"**Special nuclear material**" means

(1) plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Illinois Emergency Management Agency declares by order to be special nuclear material after the U.S. Nuclear Regulatory Commission, or any successor thereto, has determined the material to be such, but does not include source material; or

(2) any material artificially enriched by any of the foregoing, but does not include source material.

"**Survey**" means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of sources of radiation. Such an evaluation includes, but is not limited to, measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

"Thermoluminescent dosimeter or **TLD"** is a device that measures ionizing radiation exposure by measuring the amount of visible light emitted from a crystal in the detector when the crystal is heated. The amount of light emitted is dependent upon the radiation exposure upon the crystal.

"**Total effective dose equivalent**" (TEDE) means the sum of the deep dose equivalent for external exposures and the committed effective dose equivalent for internal exposures.

"**Total organ dose equivalent**" (TODE) means the sum of the deep dose equivalent and the committed dose equivalent to the organ receiving the highest dose as described in 32 Ill. Adm. Code 340.1160(a)(6).

"**Unrestricted area**" means any area to which access is not controlled by the licensee or registrant for purposes of protection of individuals from exposure to radiation and radioactive material, and any area used for residential quarters. NOTE: Licensees or registrants may control access to certain areas for purposes other than radiation protection, but such action does not affect whether the areas are unrestricted areas as defined in this Part.

"**Very high radiation area**" means an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of 5 Gy (500 rad) in 1 hour at 1 meter from a source of radiation or from any surface that the radiation penetrates. NOTE: For very high doses received at high dose rates, units of absorbed dose (e.g., gray and rad) are appropriate rather than units of dose equivalent (e.g., sievert and rem).

"**Whole body**" means, for purposes of external exposure, head, trunk (including male gonads), arms above the elbow or legs above the knee.

"**Worker**" means any individual engaged in work under a license or registration issued by the Department and controlled by a licensee or registrant, but does not include the licensee or registrant.

"**Year**" means the period of time beginning in January used to determine compliance with the provisions of 32 Ill. Adm. Code: Chapter II, Subchapters b and d. The licensee or registrant may change the starting date of the year used to determine compliance by the licensee or registrant provided that the decision to make the change is made not later than December 31 of the previous year. If a licensee or registrant changes a year, the licensee or registrant shall assure that no day is omitted or duplicated in consecutive years.

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