University of Illinois
at Urbana-Champaign

X-Ray Safety Manual

Emergency reference information:

Revised: May 2014

X-Ray Safety Manual

TABLE OF CONTENTS

1.0 Introduction

The purpose of the X-ray Safety Manual is to present regulations and recommended procedures for working with radiation-generating machines at the University of Illinois at Urbana-Champaign to protect the individual and assist members of the campus community in fulfilling their 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. 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.

This manual is written for personnel working with machines that produce radiation, including x-ray machines, particle accelerators, neutron generators, and similar devices. Equipment that is manufactured for purposes other than the generation of radiation, where the radiation is incidental to operation and in which the human radiation exposure is less than ten percent of the limit for members of the general public, may be exempted from these requirements (refer to Title 32 of the Illinois Administrative Code, Part 320.40)

The individual radiation user is responsible for understanding and conducting operations in an acceptable manner to minimize hazards to him/herself 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 are properly instructed about the nature of the radiation hazards and the necessary radiation safety procedures in the laboratory. Radiation workers must possess the necessary skills to cope with radiation safety problems effectively.

The Division of Research Safety (DRS) is responsible for assisting all users and laboratory supervisors by providing consultation and certain services in matters of radiation safety.

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

All individuals using radiation-generating machines and their supervisors must familiarize themselves with all portions of this manual that apply to their operations.

The above responsibilities are covered in greater detail in Appendix A of this manual.

2.0 Authorization of Ionizing Radiation Sources

The procurement, possession or use of radiation-generating machines is permitted only pursuant to a radiation permit issued by DRS. This section of the Manual provides instructions for the application process, responsibilities for maintaining a permit, and steps to amend or terminate a permit.

2.1 Radiation Permit Application Process

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

DRS reviews the application and prepares a radiation permit that specifies locations and conditions for use of radiation-generating machines. DRS obtains the approval signatures of the campus radiation safety officer and the Radiation and Laser Safety Committee chair. The permit is then 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, thereby 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. Before operations under the permit commence, DRS personnel will inspect the laboratory to ensure the area is effectively shielded and properly posted.

2.2 Radiation Permit Longevity

A permit is valid as long as the conditions in the permit are fulfilled and there is a need for radiation-generating devices in the laboratory. In some cases, a PI may need a radiation permit for a finite period of time. At the end of that time, the permit should be deactivated in accordance with section 2.4.

2.3 Amendments

A permit can be amended at any time. To request an amendment, the PI sends a written request to DRS personnel for the desired change. The change is evaluated. If amended, the radiation safety officer authorizes the new permit and a copy is sent to the PI. Additional signatures are not required.

2.4 Deactivating/Reactivating a Permit

If a radiation machine is inoperable, DRS should be informed. DRS will coordinate communications with Illinois Emergency Management Agency (IEMA) to have the machine deregistered.

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

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

2.5 Registration of Radiation Producing Machines

Radiation-producing machines must be registered with the Illinois Emergency Management Agency's Division of Nuclear Safety. DRS serves as the liaison with government agencies and will complete the registration for all machines on campus. Campus units are responsible for providing all required information and informing DRS of any changes in the equipment or installation. Campus units are also responsible for paying the annual registration fees associated with this requirement.

3.0 Radiation Safety Training Requirements

Each PI is responsible for providing radiation safety training to persons using radiation-generating machines under his/her supervision. Other individuals may provide the training under the PI's supervision. DRS can provide general training to personnel upon request.

The law requires that individuals be instructed in the following topics before working with radioactive materials:

- Health problems associated with exposure to ionizing 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,
- Worker's 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,
- Radiation exposure reports that workers may request.

Particular attention should be given to survey requirements, dosimetry requirements, necessary documentation, safety precautions/equipment, precautions during pregnancy, and locations where radiation sources are authorized.

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

A written, dated summary of the topics covered, list of who attended the training, and when the training occurred is required.

4.0 Analytical X-Ray Machines

Analytical x-ray systems are used to evaluate the elemental or chemical composition or microscopic structure of materials. They include x-ray diffractometers, x-ray photoelectron spectrometers, x-ray fluorescence spectrometers, and similar devices.

Analytical systems should be equipped with shielded enclosures preventing radiation exposure to operators or other personnel. Any exceptions must be reviewed and approved by the Radiation and Laser Safety Committee. Enclosures should be equipped with interlocks that either close the shutter or terminate high voltage to the x-ray tube when an interlock is compromised.

All analytical x-ray machines must have warning devices, including warning labels at each tube head and at the operating switch, a light or other visible indication for when x-rays are present, and a visible indicator of whether each shutter is open or closed.

The proper function of interlocks and shutters should be tested monthly, and records of these tests should be maintained and made available for inspection.

Unused tube ports shall be closed in a manner that prevents accidental opening.

Personnel who must work inside the enclosure must use appropriate personnel monitoring devices (described in Section 9) as determined by DRS staff.

Facilities must develop and maintain written operating instructions for each analytical x-ray machine. These procedures should include instructions for reporting actual or suspected overexposures and methods for seeking medical attention. Personnel must be instructed in these procedures before being allowed to operate any x-ray machine and the procedures must be available at the operator's location. Such instruction should be documented.

Any overexposure must be reported to RSS immediately.

Removal of old X-ray tubes may require special handling and disposal as some, such as beryllium tubes, are hazardous. Contact the Chemical Waste Section for hazardous material disposal.

5.0 Industrial Radiography

Industrial radiographic systems use non-destructive methods to examine the macroscopic structure of materials. Systems that are enclosed in shielded cabinets that limit exposure to the operators and members of the public may be exempt from some of the requirements listed below; DRS staff makes this determination.

This section does not govern industrial radiography using radionuclide radiation sources. Consult the Radiation Safety Manual for procedures for radioactive materials.

Only persons who are certified by the State of Illinois may operate industrial radiography equipment.

All industrial radiography systems must include a locking device to prevent unauthorized or accidental radiation exposure and a visible indication of when the radiation source is energized.

Records must be maintained that indicate each time an industrial radiography device is used. The record must indicate the date, the device used, the radiographer, and the location of use.

Appropriate radiation monitoring devices will be assigned by DRS (Section 9) and must be used when performing industrial radiography.

Operating instructions for each radiography unit must be developed and followed. These instructions must be available at the operator's location.

Any overexposure must be reported to DRS immediately.

6.0 Medical and Veterinary X-Rays

Medical and veterinary x-ray machines include those used for radiography, fluoroscopy, mammography, computed tomography, and therapeutic radiology. Medical x-ray machines are used when radiation is applied to humans for the purposes of diagnosis or treatment. Exposure of humans for research purposes may fall in this category, depending on the circumstances. Veterinary x-ray machines are used to apply radiation to animals for similar purposes. Exposure of animals for research purposes may also fall under this category.

Only persons who are certified or licensed by the State of Illinois may operate medical x-ray equipment. Only persons who operate under the supervision of a licensed veterinarian may operate veterinary x-ray equipment.

Medical and veterinary equipment must meet performance standards specified for many operating parameters, architectural shielding, etc. Medical and veterinary systems must be approved by DRS before they may be acquired or used.

Persons shall not be exposed to medical or veterinary x-ray machines for non-medical purposes such as training or demonstrations.

DRS will determine whether persons who are in the vicinity of operating medical or veterinary x-ray machines should wear radiation monitoring devices (Section 9). If assigned, monitoring devices must be worn whenever working around radiation sources.

Written safety and emergency procedures must be available to each person operating a medical or veterinary x-ray machine. These instructions must include restrictions that will ensure safe operation. Workers must receive annual instruction in these procedures. Documentation of training should be maintained. Guides to assist in selecting operating techniques (e.g., tube potential or kV, tube current and exposure time or mAs, phototimer setting) based on the patient's anatomical parameters must be available at each operator's position.

Whenever possible, patients should be supported and image receptors should be held by mechanical devices. If patients must be held by other persons, this responsibility should be distributed among other persons. No individual shall be assigned the duty to hold patients routinely. Such persons must remain outside the primary beam and wear appropriate safety devices (e.g., lead aprons, thyroid shields, etc.).

Fluoroscopy shall not be performed as a substitute for radiography. Personnel who attend to fluoroscopic exams must wear appropriate protective devices (e.g., lead aprons, thyroid shields).

7.0 Particle Accelerators

The term “particle accelerator” includes any device other than an x-ray machine that emits ionizing radiation as a result of acceleration of charged particles. Devices such as electrostatic particle accelerators (e.g., Cockroft-Walton and Van de Graf devices), cyclotrons, and linear accelerators are included, but it may also encompass plasma devices.

Any facility using an accelerator must shall develop written operating procedures that specify the conditions under which it may be safely operated, rules for safe operation, and emergency procedures, and make them available to the operator and maintenance personnel. Anyone operating the device must first be instructed in these operating procedures as well as the information specified in Section 3. These procedures must be available to the operator and maintenance personnel.

Use interlocks and other appropriate safety devices to ensure that personnel are not exposed to high levels of radiation during operations. A record must be maintained of each instance when an interlock or other safety device is circumvented, including the date and reason the interlock or safety device was bypassed.

Facilities that operate accelerators must maintain a current list of personnel who are authorized to use or maintain the accelerator. Units will inform DRS of any changes to this list. The name of the operator in charge must be displayed at the control console whenever the accelerator is operating.

The area surrounding the accelerator and associated components must be surveyed every three months to monitor for activation, with a record made of the accelerator operating conditions and radiation levels measured at specific control points. The radiation survey instrument used for such surveys must be checked every three months and calibrated annually.

All safety and warning devices must be checked monthly. Written records of these checks and maintenance shall be maintained for inspection.

8.0 Emergency Procedures

In the event that personnel have received high radiation exposure in addition to physical injury requiring immediate medical assistance, call MetCAD (911 from any university or personal telephone).

In each case, notify the DRS (telephone 3-2755 from university telephones or 217-333-2755 from personal telephones) as soon as practical because the emergency may demand immediate action by those on the scene. This section provides general action guidelines for individuals faced with an unexpected hazardous situation.

In case of injury, it is recommended that someone familiar with the incident remain with the injured person to provide information such as the nature of the injuries and radiation levels.

These guidelines are intended to help users to develop a safety-oriented attitude that actively anticipates potential hazards and accidents, with an eye toward prevention and a predisposition to the appropriate response to the unexpected. The PI may find it useful to draw up a written facility-specific emergency plan. The PI should arrange to have readily available specific equipment and supplies required to minimize hazards and enhance recovery.

9.0 Personnel Exposure

9.1 Occupational Exposure Limits

1. The annual limit for occupational workers is whichever of the following measures is lower:

    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).

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

Each user of radiation-generating devices shall conduct operations so that:

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

9.3 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 such that no more than 50 millirem (0.5 mSv) be received during any one month during a declared pregnancy. Furthermore, efforts shall be made to avoid substantial variation above uniform monthly exposure rate to a declared pregnant woman (see Appendix C 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 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).

9.4 Exposure Limits for Minors

The annual occupational dose limits for minors are 10 percent of the annual occupational limits specified for adult workers in Section 9.1 of this manual.

9.5 When Dosimetry Is Required

The Illinois Emergency Management Agency (IEMA) requires dosimetry for the following:

1. Adults likely to receive in one year from sources external to the body a dose in excess of 10 percent of the occupational exposure limits (Section 9.1);
2. Minors and declared pregnant women likely to receive in one year from sources external to the body a dose in excess of 10 percent of the applicable limits (Section 9.3 or Section 9.4);
3. Individuals entering a high or very high radiation area.

9.6 Personnel Exposure Records

RSS maintains exposure records for all monitored personnel. At the request of a worker, RSS shall furnish a report of the worker's dose. The report is furnished within 30 days from the time the request is made, within 30 days of termination of employment, or within 30 days after the individual's dose has been determined, whichever is latest.

9.7 ALARA (As Low As Reasonably Achievable)

The university is committed to maintaining radiation exposures to faculty, staff, students, and the public resulting from the use of radiation sources in teaching and research As Low As Reasonably Achievable (ALARA). The Radiation and Laser Safety Committee and DRS advise and assist faculty, staff, and students in all matters regarding radiation safety. Through DRS, the committee makes recommendations to campus administration on policies and procedures required for maintaining radiation exposures ALARA through the safe handling, storage, use, transport, and disposal of radiation sources. The committee will assist with interpreting the rules and regulations of the U.S. Nuclear Regulatory Commission, IEMA, and others that pertain to protection against radiation.

Sources of radiation include materials or equipment that are capable of emitting either ionizing or non-ionizing radiation. Ionizing radiation sources include radioactive materials, nuclear reactors, particle accelerators, X-ray machines, and electron microscopes. Non-ionizing radiation sources include lasers, high-intensity sources of ultraviolet light, microwave transmitters, and other devices that produce high intensity radio-frequency radiation. Both types of radiation are of concern and are under the purview of the Radiation and Laser Safety Committee and DRS.

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, DRS and radiation safety officer, 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 DRS, on matters related to the campus Radiation Safety Program. The committee is composed of faculty members representing various areas of research and teaching and members who represent the campus administration including the campus radiation safety officer.

The chancellor delegates to the Radiation and Laser Safety Committee the authority to oversee the use of radiation sources throughout the campus. Thus, the Radiation and Laser Safety Committee has the authority to permit, deny, or revoke authorization for individuals to obtain and use radiation sources at the U of I.

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

1. Review proposals for uses of radiation sources that the radiation safety officer (RSO) deems to be unusually hazardous, 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.
7. Recommend the establishment or modification of campus radiation and laser safety policies.
8. Work with the DRS to make effective use of 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 parties concerned with radiation safety.

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

3. Assign personnel monitoring devices (e.g., film badges, dosimeters) as needed, give instructions in their use, and maintain personnel monitoring records.

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

5. Assist in the design and selection of equipment, shielding, and facilities and in formulating operating procedures for new, or modifications of, existing installations or buildings.

6. 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.

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

8. 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.

9. Enforce all written directives of the committee.

10. 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.

11. 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.

12. Maintain files of federal, state, and local licenses and registrations concerned with radiation machines, and initiate applications for their renewal and/or amendment.

13. 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 provide copies to the committee.

14. 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-producing machines 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 provided 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. Routinely check protective equipment and instruments to ensure they are working properly and adequately performing their intended functions.

5. Actively seek the assistance of and cooperate with DRS to solve radiation safety problems unique to his/her situation and to correct violations of federal, state, or local rules and regulations.

6. Provide whatever action and information necessary with respect to his/her operations to assist DRS in complying with existing laws and license requirements (e.g., maintaining records, preparing reports).

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

8. Ensure that radioactive materials and work involving radiation-producing machines receive adequate supervision when the PI is away from campus for extended periods. A PI who will be absent from his/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 temporary supervisor must be sufficient to ensure that all safety requirements will be met and must be acceptable to DRS.

9. Inform DRS if: an extended departure from campus is planned or if there is any reason the obligations in this manual cannot be met.

Unit heads shall inform DRS whenever any radiation permit holder in the 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 is ultimately responsible for the safe use of the radiation-producing machines to which he or she has access, and shall:

1. Keep personal exposure as low as practical;

2. Wear assigned personnel monitoring devices in an approved manner;

3. Be familiar with and comply with all applicable sections of this manual;

4. Be familiar with potential hazards in the work area, the extent of their potential risk, and the proper means of coping with them safely;

5. Prevent unauthorized persons from having access to radiation machines;

6. Protect service personnel, allowing no maintenance or repairs of area facilities or equipment unless approved by the area supervisor and/or the DRS;

7. Notify the supervisor and DRS of unexpected difficulties;

8. Be prepared to handle accidents or injuries;

9. Notify and seek the assistance of the PI and DRS as soon as possible in emergencies.

10. Take no action that would interfere with the responsibilities of the laboratory supervisor.

Appendix B: Recommended Procedures

This appendix describes recommended procedures for frequently performed laboratory tasks. These procedures outline acceptable methods for meeting radiation safety requirements. The procedures are generic to allow for the diversity of research and facilities on campus.

Survey Procedures

Surveys are performed to monitor for failures in shielding (leaks) and activated areas. Minimum survey frequencies are specified on the radiation permit. Survey results must be documented.

A portable thin-crystal **NaI scintillation survey meter** should be used to conduct surveys around low-energy x-ray sources such as x-ray diffractometers and electron microscopes. A NaI survey meter usually displays readings in counts per minute (cpm). This type of instrument is used primarily for *detecting* leaks but not for quantifying the radiation present.

Geiger counters may be used for detecting X or gamma radiation but their detection efficiency for this purpose is low.

Ion chambers should be used to determine dose rates from X or gamma radiation.

How to Perform a Meter Survey

Go through the following steps to check the operation of a survey instrument:

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 the lowest scale. 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 response when the survey meter is switched to the lowest scale. The background rates should be <400 counts per minute for a NaI meter, <100 cpm for a Geiger counter, and <0.05 mrem/hour for an ion chamber. If background readings exceed these levels, investigate the area for unknown sources of radiation or detector contamination.

5. Instrument response check:
   Expose the survey instrument to an appropriate check source (often a thorium lantern mantle). The survey meter should respond to the check source, thus providing positive indication that the instrument is functioning properly.

Check the most likely sites for radiation such as seams in shielding, areas that could become activated, and areas that occupied by personnel.

Record survey results, survey locations, date of survey, and the name of the person performing the survey in a retrievable log.

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 obtain dosimetry, complete a *Dosimetry Request Form* (see Appendix E), and return it to DRS. Upon receipt, DRS initiates the request process with the dosimetry vendor. The turn-around time is typically one week for a “rush” order, so ensure that dosimetry requests are made in advance of the need to perform radiation-related work.

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.

Each person with assigned dosimetry must wear the dosimetry when working with sources of ionizing radiation.

The dosimeter reading is the legal record of an individual’s occupational radiation exposure. Therefore, dosimetry 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 on 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 their dosimetry must provide information to DRS personnel so that an assessment of their radiation exposure can be performed. DRS will order a replacement dosimeter as necessary.

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. 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 Radiation Safety and review the material in Appendix E. All inquiries will be kept in confidence. 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 U of I, it is rarely necessary to recommend reassignment or changes to job duties to reduce exposure.

Appendix E: Recommended Forms

Form **Page(s)**

UNIVERSITY OF ILLINOIS at URBANA•CHAMPAIGN

RADIATION PERMIT APPLICATION

Division of Research Safety
DRS
(217) 244-7233 –or- (217) 244-3538

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

Applicant Name_____ Department_____

Office Address_____

Phone_____ Email_____

RSS 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.

Building	*Room*	*Phone*

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 and carcasses. (attach additional sheets if necessary)

List all radiation detection instruments available.

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.

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.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

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 RSS 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
☐ _____	☐ _____	☐ _____

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 for 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, MC-225

Part 1……..

(Please print)

Name:_____ SSN:_____-____-_____

last first middle

Date of birth:_____ Phone _____

Room/Building where dosimetry will be stored: _____

_____

Dosimetry desired (circle one or both): Whole body badge extremity ring

Circle one: Sex: M / F Ring size (circle 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 which pertain thereto."

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:_____ / _____ Date of Calibration:_____
(model) (serial #)

Survey points should correspond to locations on survey map

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

S:/RSS/Forms/Survey 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: _____

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 millisievert) 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 one million electron volts (MeV).

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

"**Adult**" means an individual at least 18 years old.

"**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.

"**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.

"**Beam-limiting device**" means a device which provides a means to restrict the dimensions of the x-ray field.

"**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 established method 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.

"**Certification**" means the authorization by the Illinois Emergency Management Agency (IEMA) of an individual to perform industrial radiography in Illinois.

"**Certified Industrial Radiographer**" means an individual who has met prescribed training and experience requirements, has passed an approved examination, and is authorized by IEMA to perform industrial radiography.

"**Certified Industrial Radiographer Trainee**" means an individual who is authorized by the IEMA to be instructed in industrial radiography and who may perform industrial radiography while under the personal supervision of a Certified Industrial Radiographer.

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

"**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 one centimeter (1,000 milligrams per square centimeter) from external whole-body exposure.

"**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 milliroentgen 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, or 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).

"**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 accessible area 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 one 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 determining 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.

"**Interlock**" is a mechanism that prevents individuals from being inadvertently exposed to the beam of an X-ray machine.

"Ionizing Radiation" (see "Radiation")

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

"**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.

"**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.

"**Operator**" means an individual who applies ionizing radiation for diagnostic or therapeutic purposes.

"**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 accessible area 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 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 that 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.

"**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 to protect 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.)

"**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.

"**Shutter**" means an adjustable beam-limiting or attenuating device, usually made of lead, fixed to an x-ray tube housing to intercept or collimate the useful beam.

"**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.

"**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 accessible area 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 one hour at one 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.