Radiation Safety Training

Basic Radiation Safety Training for X-ray Users

for

Physics 461 & 462

Modern Physics Laboratory

Spring 2007

Radiation Safety Department, University of Tennessee
Standard Operating Procedure

Date of Implementation: 01/31/05	Revision No.: 0.0	Protocol No.: RSP-012
Protocol Title: Basic Radiation Safety Training for X-ray Users		
Drafted By: Chris Millsaps, RSS	Reviewers: ZB, TU, GS	

Purpose:
To provide basic radiation safety training to the users of x-ray producing machines located at The University of Tennessee.

Who should perform this procedure?
Principal Investigators (P.I.) who are authorized to possess x-ray producing machines
The University of Tennessee's Radiation Safety Department (RSD).

Performance Frequency:
All individual users shall be trained in the proper handling techniques prior to working with x-ray producing machines at the University of Tennessee.

Required forms:
- X-ray User Training Attendance Form
- Basic Radiation Safety Training for X-ray Users Handout
- X-ray User Training Quiz
- Appendix A *Instruction Concerning Prenatal Radiation Exposure and Declared Pregnant Worker Issues*

Required Equipment:
None

Report and Filing Requirements:
X-ray User Training Attendance Forms and training quizzes will be filed in the Radiation Safety Notebook and copies sent to the Radiation Safety Department.

Audit and review responsibilities and frequencies:
The RSO or designee will review the training presentation on a periodic frequency to assure accuracy.

Lab survey equipment and supplies:
None

Operation Procedures:
1) Each proposed worker/student is provided with a copy of the attached Basic Radiation Safety Training for X-ray Users Handout and the Quiz.
2) After reviewing the handout, the student may ask the P.I. any questions he/she may have. If the answer is not known to the P.I., the student should contact the Radiation Safety Office (RSD) for assistance prior to handling any radioactive materials.

3) Each student signs the X-ray User Training Attendance Form as proof that they received the enclosed information.
4) The quiz is administered (**Note: the quiz will be closed book**). Each student must make 80% or better to be considered adequately trained.
5) Once completed, the X-ray User Training Attendance Form and the X-ray User Training Quiz should be copied to the Radiation Safety Department for record keeping. The originals should be maintained in the Principal Investigator's Radiation Safety Notebook.

X-ray User Training
Attendance Form

Date_____ **Principal Investigator_____**

By signing this form I am acknowledging receipt of the following:

1. **Basic Radiation Safety Training for X-ray Users Handout, and**
2. **A written procedure from my P.I. for the experiment being performed, and**
3. **One of the following:**
    a. **A personnel monitoring dosimeter to measure my whole body exposure or,**
    b. **A written determination of the total whole body exposure I will receive from this experiment.**

Student/Attendee's Name (Print)	Student ID #	Student/Attendee's Signature

Basic Radiation Safety Training for X-ray Users Handout

Please refer to The Radiation Safety Department for any question or concerns regarding the safe handling of x-ray producing machines at The University of Tennessee (UT).

I. Contact Radiation Safety at the following numbers:

Main Radiation Safety Dept. phone (campus hours) 8a-5p	**(865) 974-5580**
UT Police (emergencies or after campus hours) 5p-8a	**911 or (865) 974-3114**
Radiation Safety Dept. Fax	**(865) 974-5416**
Radiation Safety Dept.Web Site	**http://web.utk.edu\~rsd**

II. Types of X-ray Machines at UT

X-ray machines have many uses on the campuses of The University of Tennessee. Primarily, these machines are used for various research purposes on non-human subjects. However, there are a few machines used for medical purposes. Medical use of x-ray machines requires additional training and more specific training than is provided in this packet. This packet is designed to inform you of certain radiation safety requirements and The University of Tennessee policies regarding the safe use of x-ray machines. Your Principal Investigator (P.I.) should provide you with experimental protocols and procedures for use with the specific machine for your research.

a. *Analytical X-ray Machines*
   Analytical x-ray systems and equipment are groups of components utilizing x-ray radiation to determine the elemental composition or examine the microstructure of materials using diffraction or fluorescence analysis.

b. *Medical or Veterinary X-ray Machines*
   Medical or Veterinary x-ray devices at The University of Tennessee are x-ray machines which are used in the diagnosis of medical or veterinary anomalies in a living subject. At The University of Tennessee most of these machines are located in the College of veterinary medicine. However there are a few machines that are used in medical research for human subjects. Some examples of Medical and Veterinary x-ray machines include Tabletop radiographic machines, dental x-ray devices, bone densitometers, and x-ray fluoroscopes.

III. Licensing and Authorization of X-ray Machines at UT

a. *The State of Tennessee Requirements for the possession and Use of X-ray Producing Machines.*

The State of Tennessee requires that all x-ray producing machines be registered with the Division of Radiological Health and that all machines be inspected according to State regulations. The regulations pertaining to the safe use of x-ray machines are found in the

State Regulation for Protection Against Radiation (SRPAR), Chapters 1200-2-6 and 1200-2-10. You can access the specifics of these regulations at the following web address: http://www.state.tn.us/sos/rules/1200/1200-02/1200-02.htm.

b. The University of Tennessee Requirements for Use of X-ray Producing Machines

In order to possess or use x-ray producing machines at The University of Tennessee, your Principal Investigator (or P.I.) must have an x-ray machine license approved by the University of Tennessee Radiation Safety Department.

To obtain a license, your P.I. must possess minimum experience and satisfy training requirements. This training packet is one of those requirements. The P.I. and everyone in his/her laboratory must pass the quiz associated with this packet before they may begin work with x-ray producing machines.

By issuing a x-ray machine license to your P.I., the Radiation Safety Department recognizes that your P.I. has assumed certain responsibilities, including assuring that everyone in the lab will have the training and equipment necessary to safely use the x-ray machine(s).

The Radiation Safety Department must be notified in advance of the intent to purchase, sell, move, give, or receive an x-ray producing machines. This advanced notice allows The Radiation Safety Department an opportunity to address any radiation safety problems and to insure that the machine is properly registered with The State of Tennessee.

State regulations require that each machine be inspected by a State Qualified Inspector on a frequency that is prescribed for each unique classification of x-ray machine found in the regulations. At The University of Tennessee, this means that most machines are inspected either on a one or two-year frequency. The Radiation Safety Department can provide you with the prescribed inspection frequency for your particular x-ray producing machine. Additionally, The University of Tennessee employs an inspector who has been qualified by The State of Tennessee to perform the required inspections. This allows for some flexibility in the scheduling of the x-ray inspection. However, State regulations require that all inspection be performed within thirty (30) days of the inspection anniversary date.

The safe use of x-ray producing machines at The University of Tennessee falls under the purview of the Radiation Safety Department (RSD) and the Radiation Safety Officer (RSO). A license to use an x-ray producing machine may be obtained by contacting the RSD at 974-5580.

Minimum qualifications to receive a license to use an x-ray machine include:

- Previous training and experience with radiation commensurate with the type(s) of x-ray machine used and,
- Successful completion of this training packet and the associated quiz and,
- Institution of appropriate radiation safety procedures in the laboratory to ensure the safety of all lab members, as well as members of the “general public” and,

- Submittal of the completed *Application for New X-ray Producing Machine Use* and its approval by the RSO.

Work with the x-ray machine may not begin until the application receives approval from the RSO. Upon approval of the application, an approved copy of the application will be sent to the P.I. for their records. The P.I. will then be authorized to take possession and use the specified x-ray machine in the location described within the application. Should any of these factors change (such as the type of machine, the location of the machine, or the ownership of the machine); the P.I. must submit an amendment request to the Radiation Safety Department prior to instituting the change.

A P.I. authorized for x-ray machine use is responsible for:

- Assuring the safe use of all radiation producing machines in his/her possession and,
- Assuring that a trained operator is present whenever the x-ray machine is in use and,
- Assuring that when the x-ray producing machine is not in use, that it is secured against unauthorized use and,
- Assuring that all users of the x-ray producing machine(s) have completed this training and have received appropriate dosimetry for the work involved or a determination for the calculated exposure to be received.
- Assuring that all users of the x-ray machine(s) have completed this training packet and the associated quiz.

IV. <u>The Safe Use of X-ray Machines</u>

a. *Definitions*

In order to safely use x-ray producing machines an understanding of some basic x-ray terminology is required. The following is a short list of terms and their definitions used in the operation of x-ray machines.

Ionizing Radiation- Ionizing Radiation is any radiation capable of displacing electrons from atoms or molecules, thereby producing ion pairs. X-rays are an example of ionizing radiation, whereas visible light is an example of non-ionizing radiation.

X-ray Radiation- Photons of electromagnetic radiation that are characteristically alike to gamma ray radiation, except in their origin. Whereas gamma rays arise from the transitions in the nuclei of radioactive atoms, x-rays are produced from extra nuclear processes involving electrons. Essentially x-ray machines produce x-rays by accelerating electrons in an electric field and projecting them toward a target. The interaction of the electrons with the target material (of high atomic number) causes the electrons to be transposed from one electron shell to another shell thereby giving off specific energy in the form of x-rays.

Exposure- A measure of the ionization produced in air by x-ray radiation. The unit used in describing exposure is the roentgen (R).

Absorbed Dose- The amount of ionizing radiation that deposits 100ergs/gram of material. The unit used in describing absorbed dose is the rad. Normally ionization in air or another gas is measured and the absorbed dose in a particular material calculated. One Roentgen results in 87.7 ergs being absorbed in 1 gram of air; if muscle tissue is placed in the same radiation beam, 1 R in air corresponds to about 95 ergs/gram. For most applications of x-rays and gamma rays, it is reasonable to assume that 1 R = 1 rad. One Roentgen is a large exposure; therefore, we more often see the term millirad (mrad, 1E-3 rad).

Dose Equivalent- The dose equivalent accounts for the difference in biological effectiveness of different types of radiation. It is the product of the absorbed dose (rad) times the quality factor (QF) of the radiation. The unit used for describing Dose Equivalent is the rem. The quality factor for x, gamma, and beta radiation is 1, therefore for these radiations 1 rad = 1 rem. The quality factor for alpha radiation is 20 and the quality factor for neutron radiation varies with energy from 2-11.

Background Radiation- Radiation from cosmic sources; naturally occurring radioactive material, including radon, and global fallout from past nuclear explosions.

Deep-dose Equivalent (DDE)- The measurement of the external radiation exposure in rem to the whole body or the *dose equivalent* at a tissue depth of 1 cm.

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

Whole Body- Means, for the purpose of external exposure, the head, the trunk (including male gonads), the arms above the elbow, and the legs above the knee.

Extremity- Means for the purpose of external exposure, the hands, the elbows, the arms below the elbow, the legs below the knee, and the feet.

Individual Dosimeter- A device designed to be worn by a single individual for the assessment of dose equivalent. A film badge and a thermo luminescent dosimeter (TLD) are examples of *individual dosimeters* employed by The University of Tennessee to monitor for dose equivalent to an individual.

Area Dosimeters- A device designed to assess the dose equivalent in a specified area. For example a TLD will be used to monitor the dose equivalent from an external radiation hazard to an unrestricted area.

Occupational Dose- The dose received in the course of employment in which the individual's assigned duties involve exposure to sources of radiation. **Note:** Occupationally exposed workers are required to be trained on safety measures involving radioactive source and radiation producing machines.

b. *Hazards*

Radiation Exposure
Radiation exposures from x-ray diffraction or fluorescence machines can be extremely hazardous. Dose rates in the primary beam of an x-ray machine can exceed 100,000 rads/minute depending on the type of x-ray producing machine. A dose of 300 rads can cause an erythema burn to the skin (erythema is the reddening of the skin that looks like a sunburn). Any part of the body momentarily placed in a beam of an x-ray machine with this type of dose rate would receive enough radiation to cause serious radiation burns. The typical skin exposure dose rates for the x-ray producing machines The University of Tennessee range from 2 mRem to 10,000 mRem. However for the monitoring period of 2003 the average whole body exposure was 14.84 mRem for the year and the maximum was 252 mRem for the year. Each of these numbers is 0.29% and 5% of the annual dose limit of 5000 mRem. Although these numbers are low radiation exposure hazard is always a concern when dealing with x-ray machines.

High Voltage
In addition to radiation hazards, the high voltage of x-ray machines can be particularly hazardous. Personnel must never tamper with high voltage equipment. Only trained professional personnel are permitted to install, repair, or modify high voltage equipment at The University of Tennessee.

c. Operation of X-ray Machines

Device Operation
Every x-ray machine differs in nature and design from one manufacturer to the next. Therefore it is imperative that all operators of the x-ray machine review both this basic x-ray training document and the manufacturer's operation manual prior to using the x-ray machine. In addition to the review of these documents, the P.I. must provide the worker with a written lab procedure for its operation and assistance with on- the job training prior to allowing solo use. If the P.I. has not used the particular x-ray machine before, training on its use from the manufacturer is necessary. Additionally, for human use x-ray machines, The State of Tennessee requires certification that the operator has undergone a state permitted training course (For details, see The State of Tennessee Health Related Board Regulation). Essentially, these courses provide certification in particular procedures for x-ray technicians. Your P.I., with The Radiation Safety Department assistance, shall provide you with the documents and training that has been approved in his/her application.

Device Security
The State of Tennessee and The University of Tennessee require that, when not attended by an authorized user, each x-ray machine is secured against unauthorized use. For most labs this will mean simply locking the door when an authorized user is not present. However in those labs where x-ray machines are accessible to unauthorized users, the device must possess a locking mechanism for preventing its

use. If your x-ray machine has a locking device available, it should be used whenever the device is not in operation.

d. ***Equipment Requirements***

Analytical X-ray Machines

Each analytical x-ray machine at The University of Tennessee must have a safety device, which prevents the entry of any portion of an individual's body into the primary beam, or a device, which cause the beam to shut off upon entry into its primary beam. This device is known as an "interlock". Any unused port must be closed off in a manner to prevent casual opening. Any x-ray unit installed after 1978 should be equipped with a shutter for each port that cannot be opened unless a collimator or a coupling has been connected to the port. Each housing shall be equipped with an interlock that shuts off the tube if it is removed from the radiation source housing, or if the housing is disassembled. All safety devices are to be tested by the user on a quarterly frequency to ensure proper operation.

Medical and Veterinary X-ray Machines

Although medical/veterinary x-ray machines are not required to have set interlocks, they are required to have some other beam limiting devices. The State of Tennessee requires that all machines have collimation devices, which restricts the x-ray beam to the area of clinical interest. Additionally, each of these machines must have lead aprons, gloves, and other personal lead shielding devices to reduce the whole body exposure to the operator of the x-ray machine.

e. ***Warnings***

All machines, which produce radiation at The University of Tennessee, must have a sign or label bearing the words "Caution –Radiation, This equipment produces x-ray radiation when energized". This posting shall be located near the switch that energizes the x-ray beam and at the tube head. Both should be located so that they are clearly visible to any person who may be working near the primary beam. Additionally, each room or area containing an x-ray producing machine shall be posted with a sign bearing the radiation symbol and the words "Caution- X-ray Equipment".

Additional Warnings for Analytical Devices

For all equipment considered to be an "open beam" x-ray devices (as determined by the guidelines in The Tennessee State Regulations for Protection Against Radiation), additional active warning devices are required these warnings include:

- A warning light, on the control panel, with the words "x-ray is on" shall light up only when the x-ray tube is activated.
- A light located near the tube housing assembly shall be used to indicate when the x-ray tube is on.

- In addition to the other warning signs, there must be a label located adjacent to each tube head bearing the words “Caution-High Intensity X-ray Beam”.
- For those machine that are controlled by shutters, there must be a readily discernable indication of the shutter status (open or closed),

f. Modification and/or Repair of the X-ray Machine

Only properly trained personnel are permitted to install, repair, or make other modifications to the x-ray generating apparatus and tube housing. The State of Tennessee requires that anyone who installs, repairs, or makes modification to an x-ray machine be specifically registered with them to perform such work. The University of Tennessee requires that the Radiation Safety Officer be notified prior to any installation, repair, modification, or disposal of an x-ray unit.

V. X-ray Machine Inspections

a. State of Tennessee Requirements

The State of Tennessee requires that all x-ray producing machines be inspected on a specific schedule, depending on the machines classification under the regulations, by an inspector registered with the State. The University of Tennessee currently employs one inspector, who is registered with The State of Tennessee to perform these inspections. These inspections test the machine for compliance with the regulations listed in The State of Tennessee Regulations for Protection Against Radiation, 1200-2-6.

Most analytical x-ray machines at The University of Tennessee are classified in the V category and are therefore inspected every two years. Currently the medical machines are classified in the III category and are therefore inspected every year. The University of Tennessee also possesses several class VI x-ray machines, which are inspected every year as well. The classification may be found on the State of Tennessee registration form that should be posted in the laboratory with the x-ray machine or by contacting the Radiation Safety Department.

b. University of Tennessee Requirements

In addition to the State required inspection, The University requires that each P.I. perform equipment safety checks on a quarterly frequency. The checkpoints for these inspections are contained in the “Quarterly X-ray Machine Checklist”. The record, of this check, must be kept for review by the Radiation Safety Department Registered X-ray Inspector.

VI. Dose and Exposure Control

a. Radiation Exposure

As mentioned above, radiation exposure is a major concern when operating many types of x-ray machines. This exposure comes primarily from the “open beam”

analytical units and from the medical/veterinary units. X-ray units that are considered to be "cabinet" units or room x-ray devices are less likely to contribute to the overall dose. Below are the dose limits for both the University of Tennessee and the State of Tennessee along with the method for determining compliance with these limits.

b. State Exposure Limits

The annual allowable whole body limit as listed in The State regulations is 5 Rem/year from deep dose exposures. State regulations require that anyone likely to receive more than 10% of the annual allowable exposure limit must be provided with an exposure-monitoring device (or dosimeter).

c. University of Tennessee Exposure Goals

To be conservative, The University of Tennessee requires that anyone who works with an x-ray unit that is classified as an "open-beam" or a medical/veterinary device be badged. However, if the x-ray device is not one of these, then a dose determination may be made by The Radiation Safety Department to calculate the maximum likely dose and to determine if personnel monitoring is required. Please contact The Radiation Safety Department at 974-5580 for assistance in determining your requirement to be monitored for radiation exposure.

d. Personnel and Area Monitors

i. TLD Monitors

As a radiation worker at The University of Tennessee you may be issued a whole body dosimeter (TLD), and an extremity (ring) dosimeter, which you are required to wear these whenever you are working with a radiation-producing machine. Additionally, if you are issued a dosimeter, your P.I. must insure that you wear it while using the x-ray machine in order to maintain their authorization to use the x-ray machine. Whole body dosimeters are correctly worn on the front of the body, between the neck and the waist. Whole body dosimeters should always face out toward incoming radiation. Extremity (ring) dosimeters should be worn on the hand most likely to come in contact with radiation. The white chip should face toward the inside of the palm.

ii. Dose Determinations

If you are not provided with a dosimeter, your P.I. should provide you with a written dose estimate for the experiment being performed. This estimate will have been calculated using information about the experimental procedures, dose measurements, x-ray machine emissions, and time, distance and shielding calculations. This estimate should provide you with the annual maximum anticipated dose from the experiments to be performed.

iii. Area Monitors

Area monitors are TLD monitors that are placed adjacent to work areas to monitor the dose to an individual member of the public and/or the dose to an un-badged worker. You may note that there are monitors placed at certain locations within and outside the x-ray lab. These have been placed by the Radiation Safety Department and should not be moved, except by the P.I. or his/her designee (an then only with RSD approval). These badges may be used in making the written determination as listed above, or in assuring compliance with the annual dose limit to an individual member of the public (100mRem/yr). Should you have any questions, please contact your P.I. or the Radiation Safety Department (974-5580).

VII. Declared Pregnant Worker Procedure

The Tennessee Division of Radiological Health, in the State Regulations for Protection Against Radiation (SRPAR), strongly encourages a female employee to report in writing to her employer/institution when she becomes pregnant. The employer/institution is then required to maintain the radiation exposure to the fetus at less than 500 millirems during the gestation period and report the fetal exposure to the pregnant female as indicated in SRPAR. Please review the included excerpts from SRPAR chapter's 1200-2-5-.32, 1200-2-5-.56, and 1200-2-5-.135. Note that the pregnancy declaration is voluntary, according to the regulation. However, once notified of the pregnancy, the employer/institution is required to limit the exposure to less than 500 millirems. Appendix A of this training handout provides useful information concerning the declaration of pregnancy by a female worker. Appendix A also includes a declaration form to be used when declaring pregnancy. If a female worker/student decides to declare her pregnancy, she should contact The Radiation Safety Department at 974-5580 to schedule a consultation. This meeting will last approximately 30 minutes and will cover the contents of Appendix A.

VII Emergency Procedures

If a situation representing a life-threatening emergency occurs in the laboratory while a radiation producing machine is being used, lab personnel should call 911 from a safe telephone. If the situation is not a life-threatening emergency while using radiation-producing machine and occurs during normal campus hours, call The Radiation Safety Department at 594-5580. If the situation is not a life-threatening emergency while using radioactive sealed source and occurs outside of normal campus hours, The Radiation Safety Staff may be reached by calling the campus police (974-3114 or 911), who will page a responder from the Radiation Safety Department. The Radiation Safety Department should be notified immediately of any emergency involving radiation producing machines including a suspected leaking collimator, loss of a radiation producing machine, damage to a radiation producing machine, malfunction of a radiation producing machine or its safety devices, or a suspected overexposure.

APPENDIX A
INSTRUCTION

CONCERNING PRENATAL RADIATION EXPOSURE

AND

DECLARED PREGNANT WORKER ISSUES

THE TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

DIVISION OF RADIOLOGICAL HEALTH

LICENSING/REGISTRATION/PLANNING SECTION
L&C ANNEX, THIRD FLOOR
401 CHURCH STREET
NASHVILLE, TENNESSEE 37243-1532
TELEPHONE NUMBER: (615) 532-0364

INTRODUCTION

This guide is to provide guidance to licensees on instructions that must be provided concerning prenatal radiation exposure. In particular, the instructions described in this guide are intended to provide the information needed by women who become pregnant to help them make an informed decision on whether or not to formally declare their pregnancy in accordance with "State Regulations for Protection Against Radiation" (SRPAR), 1200-2-5-.56.

SRPAR 1200-2-5-.56(1) requires that licensees "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). SRPAR 1200-2-5-.56(2), also, requires the licensee to make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman.

A "declared pregnant woman" is defined in SRPAR 1200-2-5-.32(16) as "a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception."

The "embryo/fetus is" defined in SRPAR 1200-2-5-.32(26) as "the developing human organism from conception until the time of birth." The embryo is an early stage of development, before the individual limbs and organs are recognizable. In humans, this development takes about eight weeks. The human organism is considered a fetus from that stage until birth.

SRPAR 1200-2-5-.71(1)(a)2. & (2)(b) specifies the requirements for monitoring for external and internal occupational dose to a declared pregnant woman. Licensees must monitor the external occupational dose to a declared pregnant woman, using an individual monitoring device, if it is likely that the embryo/fetus will receive, from sources external to the body of the declared pregnant woman, a dose in excess of 50 millirem (0.5 millisievert) during the pregnancy.

Licensees must, also, monitor, but not necessarily with individual monitoring devices, the occupational intake of radioactive material by declared pregnant women likely to receive, during the pregnancy, a committed effective dose equivalent excess of 50 millirem (0.5 millisievert). For monitored declared pregnant women, the licensee must assess the effective dose equivalent delivered to the embryo/fetus during the pregnancy. The NRC Regulatory guide 8.36, "Dose to Radiation Dose to the Embryo/Fetus" provides guidance on calculating the radiation dose to the embryo/fetus.

SRPAR 1200-2-5-.135(6) requires the licensee maintain records of dose to an embryo/fetus if monitoring was required, and it requires that the records of the dose to the embryo/fetus be kept with the records of the dose to the declared pregnant woman. The NRC's Regulatory Guide 8.7, "Instructions for Recording and Reporting Occupational Radiation Exposure Data, " includes recommendations concerning records of dose to the embryo/fetus. This guide recommends that "licensees should be sensitive to the issues of personal privacy with regard to embryo/fetus. If requested by the monitored woman, a letter report may be provided to subsequent licensees to document prior embryo/fetus dose." The declaration of pregnancy must, also, be kept on file but may be maintained separately from the dose records. The licensee must retain each required form or record until the Department terminates each pertinent license requiring the record.

WHO SHOULD RECEIVE INSTRUCTIONS

Instructions concerning prenatal radiation exposure and its risks to the embryo/fetus should be provided to workers before they are allowed to work in a restricted area. Each supervisor of a female worker who will work in a restricted area should, also, receive the instruction.

HOW TO PROVIDE INSTRUCTION

The instruction should be presented both orally and in written form and should include, as a minimum, the information in the Appendix to this guide. Each worker should be given a copy of this guide and given the opportunity to ask questions on the instructions.

EMPLOYER'S POLICY ON DECLARED PREGNANT WOMEN

The instruction provided should describe the employer's specific policy on declared pregnant women. In particular, the instruction should include a description of the employer's policies with respect to changes, if any, that may affect the declared pregnant woman's work situation as a result of her filing a written declaration of pregnancy consistent with SRPAR 1200-2-5-.56.

DURATION OF LOWER DOSE LIMITS FOR EMBRYO/FETUS

The lower dose limit is in effect until the declared pregnant woman:

(1) Is known to have given birth;
(2) Informs the licensee that she is no longer pregnant; or
(3) Informs the licensee that she no longer wants to be considered a declared pregnant woman.

APPENDIX

This Appendix describes information that you should know about the radiation exposure of pregnant women. In particular, radiation protection regulations allow a woman to decide whether she wants to formally declare her pregnancy to her employer, thereby taking advantage of the special dose limits provided to protect the developing embryo/fetus. This Appendix provides information on the potential effects of declaring a pregnancy in order to help women make informed decisions on whether or not to declare pregnancy. The information is provided in the form of answers to a woman's questions.

MAKING THE DECISION TO DECLARE PREGNANCY

1. If I become pregnant, am I required to inform my employer of my pregnancy?

   No. It is your choice whether to declare your pregnancy to your employer. If you choose to declare your pregnancy, a lower radiation dose limit will apply to you. If you choose not to declare your pregnancy, you will continue to be subject to the same radiation dose limits that apply to non-pregnant workers even if you are visibly pregnant.

2. If I inform my employer in writing of my pregnancy, what happens?

   The amount of radiation that you will be allowed to receive will decrease because there is a lower dose limit for the embryo/fetus of female workers who have formally declared their pregnancy in writing. Ordinarily, the radiation dose limit for a worker is 5 rem (50 millisieverts) in a year. But if you declare in writing that you are pregnant, the dose to the Embryo/fetus is generally limited to 0.5 rem (5 millisieverts) during the nine-month pregnancy, which is one-tenth of the dose limit that an adult worker may receive in a year. In addition, the licensee must make an effort to avoid substantial variation above a uniform monthly dose rate so that all the dose received does not occur during a particular time of the pregnancy. This may mean that, if you declare your pregnancy, you may not be permitted to perform some of your normal job functions and you may not be able to have emergency response responsibilities.

3. Why do the regulations have a lower dose limit for a woman who has declared her pregnancy than for a normal worker?

   The purpose of the lower limit is to protect the embryo/fetus. Scientific advisory groups recommend (References 1 and 2) that the dose before birth be limited to about 0.5 rem rather than the 5 rem (50 millisieverts) occupational annual dose limit because of the sensitivity of the embryo/fetus to radiation. Possible effects include deficiencies in the child's development, especially the child's neurological development, and an increase in the likelihood of cancer.

4. What effects on development can be caused by radiation exposure?

   The effects of large doses of radiation on human development are quite evident and easily measurable, whereas at low doses the effects are not evident or measurable and therefore must be inferred. For example, studies of the effects of radiation on animals and humans demonstrate clearly and conclusively that large doses of radiation - such as 100 rem (1 Sievert) - cause serious developmental defects in many of the body's organs when the radiation is delivered during the period of rapid organ development (References 2, 3, 4, and 5).

   The developing human brain has been shown to be especially sensitive to radiation. Mental retardation has been observed in the survivors of the atomic bombing in Japan in-utero during sensitive periods. Additionally, some other groups exposed to radiation in-utero have shown lower than average intelligence scores and poor performance in school (Reference 4).

   The sensitivity of the brain undoubtedly reflects its structural complexity and its long developmental period (and hence long sensitive period.) The most sensitive period is during the 8th to 15th weeks of gestation followed by a substantially less sensitive period for the 2 months after the 15th week (Reference 4). There is no known effect on the embryo/fetus' developing brain during the first two months of pregnancy or the last three months of pregnancy (Reference 4).

   No developmental effects caused by radiation have been observed in human groups at doses at or below the 5 rem (50 millisievert) occupational dose limit. Scientists are uncertain whether there are developmental effects at doses below 5 rems (50 millisieverts). It may be that the effects are present but are too mild to measure because of the normal variability from one person to the next and because the tools to measure the effects are not sensitive enough. Or, it may be that there is some threshold dose below which there are no developmental effects whatsoever.

   In view of the possibility of developmental effects, even if very mild, at doses below 5 rem (50 millisieverts), scientific advisory groups consider it prudent to limit the dose to the embryo/fetus to 0.5 rem (5 millisieverts) (Reference 1 and 2). At doses greater than 5 rem (50 millisieverts), such as might be received during an accident or during emergency response activities, the possibility of developmental effects increases.

5. How much will the likelihood of cancer be increased?

   Radiation exposure has been found to increase the likelihood of cancer in many studies of adult human and animal groups. At doses below the occupational dose limit, an increase in cancer incidence has not been proven, but is presumed to exist even if it is too small to be measured. The question here is whether the embryo/fetus is more sensitive to radiation than an adult. While evidence for increased sensitivity of the embryo/fetus to cancer induction from radiation exposure is inconclusive, it is prudent to assume that there is some increased sensitivity. Scientific advisory groups assume that radiation exposure before birth may be 2 or 3 times more likely to cause cancer over a person's lifetime than the same amount of radiation received as an adult (Reference 1).

6. How does the risk to the embryo/fetus from occupational radiation exposure compare to other avoidable risks?

   The risk to the embryo/fetus from 0.5 rem or even 5 rem of radiation exposure is relatively small compared to some other avoidable risks. Of particular concern is excessive consumption of alcohol during pregnancy. The U.S. Public Health Service has concluded that heavy alcohol consumption during pregnancy (three drinks per day and above) is the leading known cause of mental retardation (Reference 6). Children whose mothers drank heavily during pregnancy may exhibit developmental problems such as hyperactivity, distractibility, short attention spans, language difficulties, and delayed maturation, even when their intelligence is normal.

   In studies tracking the development of children born to light or moderate drinkers, researchers have, also, correlated their mothers' drinking patterns during pregnancy with low birth weight, decreased attention spans, delayed reaction times, and lower IQ scores at age 4 years. Youngsters whose mothers averaged three drinks per day during pregnancy were likely to have IQs averaging five points lower than normal.
   Cigarette smoking may, also, harm the unborn (Reference 6). There is a direct correlation between the amount of smoking during pregnancy and the frequency of spontaneous abortion and fetal death. Children of mothers who smoke while pregnant are more likely to have impaired intellectual and physical growth. Maternal smoking has, also, been associated with such behavioral problems in offspring as lack of self-control, irritability, hyperactivity, and disinterest. Long-term studies indicate that these children perform less well than matched youngsters of nonsmokers on tests of cognitive, psychomotor, language and general academic functioning.

   Alcohol and smoking are only examples of other risks in pregnancy. Many other toxic agents and drugs, also, present risk. In addition, many factors that cannot be controlled present risk. There is an increased risk in pregnancy with increasing maternal age. Maternal disease may be an important risk factor. Malnutrition, toxemia, and congenital rubella may be associated with birth defects. Maternal diabetes and high blood pressure have been associated with problems in the newborn. In addition, many birth defects and developmental problems occur without an obvious cause and without any obvious risk factors. For example, viruses that we may not even be aware of can cause defects, and defects can arise from spontaneous random errors in cell reproduction. But these are things that we cannot do anything about.

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 to occupational radiation at all, but your employer may not have such a position or may not be willing to provide you with a job involving no radiation exposure. Even if you receive no occupational exposure at all, you will receive a dose around 0.3 rem (3 millisieverts) from unavoidable natural background radiation (Reference 7).

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

   Only your employer can tell you what effect a declaration of pregnancy will have on your job status. As part of your radiation safety training, your employer should tell you its policies with respect to the job status of declared pregnant women. In addition, we recommend that, before you declare your pregnancy, you talk to your employer and ask what a declaration of pregnancy would mean specifically for you and your job status. However, if you do not declare your pregnancy, the lower exposure limit of 0.5 rem (5 millisieverts) does not apply.
   It is most likely that your employer will tell you that you can continue to perform your job with no changes and still meet the regulatory limit for exposure to declared pregnant women. A large majority of licensee employees (greater than 90%) receive, in nine months, occupational radiation doses that are below the 0.5 rem (5 millisieverts) limit for declared pregnant women.

   If the dose you currently receive is above the 0.5 rem (5 millisievert) dose allowed for a declared pregnant woman, it is quite likely that your employer can and will make a reasonable accommodation that will allow you to continue performing your current job, for example, by having another qualified employee perform a small part of the job that accounts for much of the radiation exposure.
   On the other hand, it is possible, although not common, that your employer will conclude that there is no reasonable accommodation that can be made without undue hardship that would allow you to do your job and remain within the dose limits for a declared pregnant woman. In these few instances, your employer may conclude that you can no longer be permitted to do your current job, that you must be removed from your job, and that there is no other job available for someone with your training and job skills.

   If your employer concludes that you must be removed from your current job in order to comply with the lower dose limits for declared pregnant women, you may be concerned about what will happen to you and your job. The answer to that depends on your particular situation. In addition, telephone numbers that may be useful for obtaining information are listed in the additional information section of this appendix.

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

   You must provide your name, a written statement 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 your employer. A sample form letter that you can use is included at the end of these questions and answers. You may use the letter or write your own letter.

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

    No. No proof is necessary.

11. Can I tell my employer orally rather than in writing that I am pregnant?

    No, the statement must be in writing. The regulations require that the statement must be in writing. An oral statement is the same as not telling your employer that you are pregnant.

12. If I have not declared my pregnancy in writing, but my employer notices 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 choice of whether to declare your pregnancy and thereby work under the lower dose limits is your choice, not your employer's. Your employer may not remove you from a specific job because you appear pregnant.

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

    No, the lower limits apply only if you declare that you are already pregnant.

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

    If you have declared your pregnancy in writing, you should promptly inform your employer that you are no longer pregnant. The regulations do not require the revocation of a declaration be in writing, but we recommend that you revoke the declaration in writing to avoid confusion. Also, your employer may insist upon a written revocation for its own protection. If you have not declared your pregnancy in writing there is no need to inform your employer of your new, non-pregnant status.

    If you have a miscarriage and become pregnant again before you have revoked your original declaration of pregnancy, you should submit a new declaration of pregnancy because the date of conception has changed.

15 How long is the lower dose limit in effect?

    The dose to the embryo/fetus must be limited until (1) your employer knows you have given birth, (2) you inform your employer that you are no longer pregnant, or (3) you inform your employer that you no longer wish to be considered pregnant.

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 limits no longer apply.

17. What if I work under contract at the licensed facility and my employer is not the licensee?

    The regulations state that you should formally declare your pregnancy to your employer in writing. You can ask your employer to give a copy of your declaration to the licensee, or you may give a copy of your written statement directly to the licensee.

18. Can I tell my employer I am pregnant when I know I am not, in order to work under the lower dose limit?

The purpose of this regulation is to allow a woman to choose a heightened level of protection from radiation exposure for the embryo/fetus during her pregnancy. That purpose would not be served by intentionally declaring yourself to be a pregnant woman when you know you are not pregnant. There are no Department regulatory requirements specifically addressing the actions your employer might take if you provide a false declaration. However, nothing in the Department's regulations would prevent your employer from taking adverse action against you for deliberating lying.

STEPS TO LOWER RADIATION DOSE

19. What steps can I take to lower my radiation dose?

Your employer should already have explained that to you as part of the instructions that licensees must give to all workers. However, you should ask your supervisor or the radiation safety officer whether any additional steps can be taken.

The general principles for maintaining exposure to radiation as low as reasonable achievable are summarized below. You should already be applying these principles to your job.

External Radiation Exposure

External radiation is radiation you receive from radiation sources or radioactive materials that are outside your body. The basic principles for reducing external radiation exposure are time, distance, and shielding - decrease your time near radiation sources, increase your distance from the radiation source, and increase the shielding between yourself and the radiation source. You should work quickly and efficiently in a radiation area so that you are not exposed to the radiation any longer than necessary. As the distance is increased from the source of radiation, the dose decreases. When possible, you should work behind shielding. The shielding will absorb some of the radiation, thus reducing the amount that reaches you.

Internal Radiation Exposure

Internal radiation is radiation you receive from radioactive materials that have gotten into your body, generally entering with the air you breathe, the food you eat, or the water you drink. Your employer will have specific procedures to minimize internal radiation exposure. Those procedures probably incorporate the following general precautions that should be taken when you are working with radioactive materials that are not encapsulated:

1. Wear lab coats or other protective clothing if there is a possibility of spills.
2. Use gloves while handling unencapsulated radioactive materials.
3. Wash hands after working with unencapsulated radioactive materials.
4. Do not eat, drink, smoke, or apply cosmetics in areas with unencapsulated radioactive material
5. Do not pipette radioactive solutions by mouth.

These basic principles should be incorporated into the specific methods and procedures for doing your individual work. Your employer should have trained you in those specific rules and procedures.

If you become pregnant, it is a good time to review the training materials on the methods and procedures that you were provided in your training. You can, also, talk to your supervisor

about getting refresher training on how to keep radiation doses as low as reasonably achievable.

ADDITIONAL INFORMATION

You can find additional information on the risk of radiation in NRC's Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure."

You can, also, telephone our Department at (615) 532-0364.

If you believe you have been discriminated against, you should contact the U.S. Equal Employment Opportunity Commission (EEOC), 50 Vantage Way 202, Nashville, Tennessee 37228, phone number (615) 736-5820, or an EEOC Field Office by calling 1-800-669-4000 or 1-800-669-EEOC. For individuals with hearing impairments, the EEOC's TDD number is 1-800-800-3302.

REFERENCES

1. National Council on Radiological Protection and Measurements, *Limitation of Exposure to Ionizing Radiation*, Report No. 116, Bethesda, MD. 1993. [The National Council on Radiological Protection and Measurements (NCRP) is a nonprofit corporation chartered by Congress in 1964 to collect information and make recommendations on protection against radiation. This publication, on pages 37-39, summarizes the conclusions of the NCRP with respect to protection of the human embryo/fetus against radiation. This publication should be available through most good public library systems and most good university libraries. Your employer may, also, have a copy.]

2. *ICRP Publication 60 - 1990 Recommendations of the International Commission on Radiological Protection, Ann. ICRP 21: No. 1-3*, Pergamon Press, 1991. [This publication, on pages 146-149, summarizes the conclusions of the ICRP on the effects of radiation on the human embryo/fetus].

3. *Health Effects of Exposure to Low Levels of Ionizing Radiation (BEIR V),* Committees on the Biological Effects of Ionizing Radiation, National Research Council, National Academy Press, Washington, D.C., 1990.

4. United Nations Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation*, United Nations, New York, 1993.

5. National Council on Radiation Protection and Measurements, *Considerations Regarding the Unintended Radiation Exposure of the Embryo, Fetus, or Nursing Child*, NCRP Commentary No. 9, National Council on Radiation Protection and Measurements, Bethesda, Maryland, 1994.

6. *Alcohol, Tobacco, and Other Drugs May Harm the Unborn*, U.S. Department of Health and Human Services, Public Health Service, Alcohol, Drug Abuse, and Mental Health Administration, DHHS Publication No. (ADM) 92-1711, Rockville, Maryland, 1990.
7. National Council on Radiological Protection and Measurements, *Exposure of the Population in the United States and Canada from Natural Background Radiation*, Report No. 94. Bethesda, Maryland. 1987.

FORM LETTER FOR DECLARING PREGNANCY

This form letter is provided for your convenience to make your declaration of pregnancy, you may fill in the blanks in this form letter and give it to your employer or you may write your own letter.

DECLARATION OF PREGNANCY

To: _____
(Name of your supervisor or other employer representative)

I am declaring that I am pregnant. I believe I became pregnant in _____, _____ (only the month and year need be provided).

I understand that my occupational radiation dose during my entire pregnancy will not exceed 0.5 rem (5 millisieverts) (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.

If I find out that I am not pregnant, or if my pregnancy is terminated, I will promptly inform you in writing that my pregnancy has ended. **(This promise to inform your employer in writing when your pregnancy has ended is optional. The sentence may be crossed out if you wish.)**

_____
(Your signature)

_____
(Your name printed)

_____
(Date)