Radiation Safety Training

Basic Radiation Safety Training for Sealed Source Users

for

Physics 461 & 462

Modern Physics Laboratory

Spring 2007

Radiation Safety Department, University of Tennessee
Standard Operating Procedure

Date of Implementation: 11/22/04	Revision No.: 0.0	Protocol No.: RSP-009
Protocol Title: Training for Sealed Source Users		
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Purpose:
To provide basic radiation safety training to the users of sealed sources located at The University of Tennessee.

Who should perform this procedure?
Principal Investigators (P.I.) who are authorized to possess radioactive sealed sources by The University of Tennessee's Radiation Safety Committee (RSC).

Performance Frequency:
All individual users shall be trained in the proper handling techniques prior to working with radioactive sealed sources at the University of Tennessee.

Required forms:
- Sealed Source Training Attendance Form
- Sealed Source Radiation Safety Training Handout
- Sealed Source Training Quiz
- Appendix A *Instruction Concerning Prenatal Radiation Exposure and Declared Pregnant Worker Issues*

Required Equipment:
None

Report and Filing Requirements:
Sealed Source 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 Sealed Source Radiation Training 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 Sealed Source 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 Sealed Source Training Attendance Form and the Sealed Source 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.

Sealed Source Training
Attendance Form

Date_____ **Principal Investigator_____**

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

1. **Sealed Source Training 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

Sealed Source Radiation Safety Training Handout

Please refer to The Radiation Safety Department for any question or concerns regarding the safe handling of sealed radioactive sources at The University of Tennessee.

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**

Sealed source use at UT

State and Federal regulations control the use of radioactive material at The University of Tennessee. The University has been issued a license that allows the use of radioactive materials and also requires the University to control and monitor the use of these materials. The safe use of radioactive materials is best accomplished when the end user and radiation safety personnel act in cooperation.

Sealed sources are radioactive materials sealed inside metal or plastic and can take many different forms. All forms share some type of encapsulation that prevents their radioactive contents from leaking or dispersing, barring tampering or a severe accident. In some forms, the radioactive material is an inherent part of the source and cannot be separated. Almost all "sealed sources" can be handled without the concern that radioactive material will rub off or be dispersed onto hands or clothing. There is, however, reason to be concerned about exposure to radiation emitted from the sealed source.

Sealed source forms include:

- Plated sources

  In this form, the radioactive material coats a disk or planchette. Mylar, aluminum, steel, or plastic may cover this coating, depending upon the type of radiation.

- Capsules

  In this form, a capsule usually made of metal surrounds the radioactive material. These sources are often placed onto the end of metal or plastic handling rods. Another example is a capsule, which contains a mixture of radioactive compounds and is welded or sealed closed.

- Activated metal

  In this form, a metal wire or foil has been exposed to a neutron flux to irradiate the metal and create a radioactive isotope from the original material. This form of sealed source may have a plastic or epoxy coating to protect the activated metal. In some instances, however, the metal is not protected.

Many commonly used laboratory devices, such as gas chromatographs with electron capture detectors, liquid scintillation counters, and static eliminators, also contain sealed sources.

Authorized user of sealed sources

In order to possess or use radioactive sealed sources (or devices containing sealed sources) at The University of Tennessee, your Principal Investigator (or P.I.) must have a radioactive materials license approved by the University of Tennessee Radiation Safety Committee.

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 sealed sources.

By issuing a radioactive materials license to your P.I., the Radiation Safety Committee 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 radioactive source(s).

The safe use of sealed sources

Sealed sources present an external radiation hazard as opposed to a contamination hazard. Sealed sources can emit any type of ionizing radiation, including alpha particles, beta particles, gamma rays, x-rays, and neutrons.

When working with any radioactive materials, the principal concern is controlling exposure to radiation. Since any radiation exposure presumably involves some risk to the individual involved, the level of exposure received should be worth the result that is achieved. In principle, the objective of radiation protection is to balance the risks versus the benefits from activities that involve radiation. Different uses of ionizing radiation warrant consideration of different exposure guidelines or means to reduce exposure.

An essential facet of radiation protection practices is the ALARA (As Low As Reasonably Achievable) philosophy. The ALARA concept gives primary importance to the principle that exposure should always be kept low as practicable.

There are several simple ways that radiation exposure can be reduced when working in the lab. The main principles are Time, Distance, and Shielding. Each is described below.

- Time:

  When working with radiation you should be aware that radiation exposure is directly proportional to the time spent in the field. If the time spent in a given radiation field is doubled, the worker's exposure is doubled. What thought processes or actions will assist with this exposure reduction tool? These might include: not removing the source from its storage area until the last possible moment, thoroughly understanding the experiment by completing several "dry-runs" prior to introducing the source to the experiment, and understanding where the radiation beam is present, i.e.:

  1. Does the radiation stream from the source over 360° or is the beam collimated in a particular direction?
  2. Does the experimental apparatus include adequate "beam stops"?
  3. Is the source removed from the experiment at the earliest opportunity?
  4. Has everyone who might come into contact with the experiment or work in the vicinity been informed of the presence of radiation?

- Distance

  In many cases this control is more important than controlling time in the radiation field. For those sources that can be treated as a "point" source (i.e. the distance between you and the source is greater than the largest diameter of the source), the dose received is inversely proportional to the SQUARE of the distance of separation. Thus the distance of separation between a person and a source has greater relative influence on dose than does the time factor.

  As an example, consider a person who is exposed to a radioactive point source for 5 seconds at one meter or for 10 seconds at two meters. Which condition would provide the lowest exposure? If we consider that Exposure = (Time)/(Distance)^2.

  1. For the one-meter example: Exposure = $5/(1)^2 = 5$ units.
  2. For the two-meter example: Exposure = $10/(2)^2 = 2.5$ units. Clearly the two-meter distance leaves the worker with the lower radiation exposure.

  What thought processes or actions will assist with this exposure reduction tool? They might include the use of tongs to handle sources (this should only be done, of course, when it does not jeopardize the integrity of the source or create handling problems) and standing well away from the radiation beam or source.

- Shielding:

  A simple, yet effective, way of reducing radiation exposure, either in conjunction with or when the previous methods cannot be used, is by placing appropriate shielding between you and the source. What thought processes or actions will assist with this exposure reduction tool? They might include the use of shielding to collimate the beam to a defined area.

  To properly utilize this method, one must understand what shields work best for various types of radiation. Selecting the most appropriate shielding material depends upon a number of factors, including the type of radiation, the energy of the radiation, and the density of the materials to be used as shielding. For this reason, the Radiation Safety Department should be involved in helping laboratory staff design the necessary shielding for the source(s).

  1. Shielding pure alpha sources is not necessary in the laboratory (keep in mind, however, that many alpha sources often have a secondary gamma or x-ray emission associated with them). The dead layer of skin on your body will stop nearly all alpha radiation.
  2. Shielding beta sources is best accomplished with low atomic number materials. Less dense materials such as Plexiglas or plastic provide nominally thick shields that attenuate the beta particles and minimize the production of *bremsstrahlung* x-ray radiation (a type of x-ray produced by beta particles interacting with materials of high atomic number). All, except the most energetic beta sources can be adequately shielded with a centimeter or two of Plexiglas. Materials, such as lead and steel, are discouraged for use with beta sources and can actually increase your radiation exposure due to the production of *bremsstrahlung* x-rays. Beta particles can penetrate up a centimeter into your skin and should be considered an external radiation exposure hazard.
  3. When shielding gamma or x-ray sources, the energy of the source and the density and composition of the shielding material must be taken into consideration. For all except the most energetic sources lead foil or moderately thick lead sheeting can be used to shield the source. Metals, such as steel or iron, can also be used to shield gamma or x-ray sources. The exact design of gamma shielding can be quite complex, and surveys may need to be performed to ensure the adequacy of the shield design. Gamma rays and x-rays emissions are very penetrating to the human body and are a significant external radiation hazard.
  4. Hydrogen-rich materials such as water or paraffin are often used to shield neutron sources. The hydrogen atoms work to absorb the energy of and thermalize (or slow down) the neutrons in order to make them less destructive to materials in their path. Many neutron sources also emit gamma or x-rays, and so the shielding design for these sources may become quite complex. Neutrons can cause serious damage to tissue as they impart their energy to the hydrogen-containing molecules in your body.

Operator Requirements

All users of sealed sources or machines containing sealed sources are required to review this package and pass the quiz before using radiation. This is a requirement of the campus-wide Radiation Safety Committee and is part of your P.I.'s radioactive materials license and application.

Anyone working with radiation should be familiar with the experimental procedures for which the radiation will be used. The P.I. should provide these procedures, in written form, to each person involved in the experiment. If you have questions about proper operating procedures for working with radiation or if you have questions about the services provided by The Radiation Safety Department, please refer to the Radiation Safety Notebook that is available in each approved laboratory or by calling Radiation Safety at 974-5580.

Operating Procedure

All sealed sources at the University of Tennessee must be periodically tested for leakage by the Radiation Safety Department. Currently, the Department is required by State Regulations to leak test each source every six months. Additionally, each sealed source must be physically inventoried every six months by the Radiation Safety Department. Both of these requirements are met and documented at the same time (typically, June and December). In addition to this requirement, the authorized user should perform his/her own inventory in the quarters not covered by the Department (March and September).

All sealed sources should be maintained within approved storage cabinets or safes, or at a designated location within the laboratory. Each storage location should have an inventory, provided by The Radiation Safety Department, of the sources stored at that site. Whether or not the storage location should contain shielding material depends on the type of radiation emitted by the source(s). For many gamma or x-ray emitters, some form of shielding, either integral to the source holder or maintained within the storage cabinet itself, will be necessary.

Each relocation of a source from its storage site or each use of a source in an unshielded position must be documented on the Sealed Source Utilization Log, which is kept near the source location. Sources may only be transported within the building in which they are authorized for storage. If transportation to another building is necessary, The Radiation Safety Department must be contacted for assistance. Sources (or the rooms which they occupy) must be locked when not under the direct supervision of an authorized user. The Sealed Source Utilization Log should be updated when the source is returned to its storage and/or shielded location.

Only the Radiation Safety Department may transport radioactive sources between non-contiguous buildings. As much notice as possible (at least 2-3 weeks) should be given to The Radiation Safety Department prior to transport to allow for the preparation of required paperwork and transport logistics.

Visual Warnings

Each laboratory using or storing radioactive materials at The University of Tennessee is required to post warning signs such that the public (or students) will be aware of a radiation hazard in the vicinity. The visual warning is required for both the equipment that contains the source and the outer door to the room in which the source is contained.

All signs must contain the tri-foil radiation symbol and the words "Caution—Radioactive Materials" in the colors magenta and yellow. Signs are available from the Radiation Safety Department.

Leak Test & Inventory of Sources

As mentioned before, all sealed radioactive sources are required to be tested for leakage and to be inventoried on a six-month frequency by the Radiation Safety Department.

Leak test are accomplished by wiping a piece of filter paper (wipe smear) across a source or source housing. Any radioactive contamination leaking from the source can then be measured by analyzing the filter paper in a liquid scintillation counter, a multi-channel analyzer, or a thin end window counter.

- If sample analysis shows contamination that is ≥ 0.005 μCi, the source is required to be removed from use and either repaired or disposed of properly. This level of leakage requires immediate notification of The State of Tennessee.
- No action is required for sample analysis showing contamination <0.005 μCi.

When the leak tests are performed by The Radiation Safety Department, an inventory of all radioactive sources will be performed. The sources are also required to be inventoried by the P.I. three months after the inventory by The Radiation Safety Department (typically March and September). If a source is found to be missing, The Radiation Safety Department must be notified as soon as possible so that a search for the source can begin. The loss of a source at the University of Tennessee requires immediate notification of the state regulatory agency. An inventory of the current source activities is provided each time that The Radiation Safety Department inventories a storage location.

Dose and Exposure Control

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). To be conservative, The University of Tennessee requires that anyone who handles a sealed source must be badged. However, if direct handling of the sealed source is not involved, a dose determination must 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.

Whole body dosimeters are correctly worn on the front of the body, between the neck and the waist. 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.

If you are not provided with a dosimeter and are not handling sealed sources, 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, sealed source activities, and time, distance and shielding calculations. Should you have any questions, please contact your P.I. or the Radiation Safety Department (974-5580).

Allowed levels of radiation exposure to laboratory personnel using radioactive sources at the University of Tennessee is governed by state regulations. The maximum whole body exposure for occupationally exposed personnel is 5 rem per year. The University of Tennessee's ALARA goals for radioactive exposure are 10% of the regulatory limit, or 500 mRem per year.

Contamination is not normally a concern with sealed sources. However, if there is any reason to suspect that a source is leaking or that contamination is present in the laboratory, call The Radiation Safety Department immediately (974-5580).

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.

Emergency Procedures

If a situation representing a life-threatening emergency occurs in the laboratory while a radioactive sealed source is being used, lab personnel should call 911 from a safe telephone. If the situation is not a life-threatening emergency while using radioactive sealed source 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 radioactive material including a suspected leaking source, loss of a sealed source, damage to a sealed source, malfunction of a device that contains a sealed source, or a suspected overexposure to a sealed source.

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 a 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)