

EXPOSURE CONTROL

1. INTRODUCTION

Dose Limits

The United States Nuclear Regulatory Commission has established an annual limit on the radiation dose individuals may receive. The limits were developed using international recommendations and risk estimates. The Colorado Department of Public Health and Environment (CDPHE) is responsible for enforcing compliance with these limits in the State of Colorado. Notice that the limits are significantly lower for children and members of the general public than for radiation workers in laboratories.

<u>Individual</u>	<u>Annual Dose Limit</u>	
Radiation Worker		
Whole Body (penetrating radiation)	50 mSv	(5,000 mrem)
Lens of the Eye	150 mSv	(15,000 mrem)
Skin and Extremities	500 mSv	(50,000 mrem)
Individual Organs (internal dose)	500 mSv	(50,000 mrem)
Embryo/Fetus (during gestation period)	5 mSv	(500 mrem)
Member of General Public	1 mSv	(100 mrem)
Minor (under 18 years old)	1 mSv	(100 mrem)

Exposure to radiation does not automatically determine the dose, because of mitigating factors such as:

- * The energy and type of radiation emitted from the source;
- * The amount of time spent near the radioactive source;
- * The distance from the source; and
- * Any shielding used by the individual.

Dose is a measurement of the radiation energy which is absorbed by tissue. Please refer to the Introduction chapter for more information regarding time, distance, and shielding and fundamental principles of radiation safety.

Relative Risk

How will radiation exposure increase the chance (RISK) of cancer death?

The National Research Council established committees on the Biological Effects of Ionizing Radiations (BIER) to prepare a series of reports to advise the U. S. government on the health consequences of radiation exposures. One of these committees, BIER VII, published a report in 2006 titled *Health Risks from Radiation*. In this report, the BIER VII committee reaffirmed the findings from the BEIR V committee (report published in 1990), which indicated that the risk of cancer death is 0.08% per rem for doses received rapidly (acute exposure). The risk from doses received over a long period of time

(chronic exposure) might be as little as 0.04% per rem or 2-4 times lower. These risk estimates are averages considering males and females, all age groups, and all forms of cancer. Significant uncertainty is associated with the estimates. BEIR VII also noted that relatively high levels of radiation exposure increased the risk of heart disease and stroke, but did not give specific risk estimates. The BIER VII committee stated that every exposure to radiation produces a corresponding increase in cancer risk (linear non-threshold, or *stochastic*, model). Most scientists believe that this is a conservative estimate or model of risk from low doses of radiation.

In the United States, the current death rate from cancer is approximately 20-25%, therefore out of any group of 10,000 United States citizens, about 2,000 will die of cancer. Although about 20% of the population will die from cancer, it is impossible to say which specific individuals will die.

Based on these assumptions, in a population of 10,000 people exposed to one rem (per person to the whole body), approximately eight additional deaths ($0.0008 \times 10,000 \times 1 \text{ rem}$) would be due to the radiation exposure. So, instead of the 2,000 people expected to die from cancer naturally, now there are 2,008. This small increase in the expected number of deaths would not be seen in this group, due to natural fluctuations in the rate of cancer. It is not certain that 8 people will die, but there is a risk of 8 additional deaths in a group of 10,000 people if they all receive one rem instantaneously (acute exposure). If the exposure is received over a long period of time (chronic exposure), the risk would be reduced to less than 4 additional expected fatal cancers.

Relative risk must be balanced with the benefit from the exposure to radiation. The risk is a small increase in developing fatal cancer. Risk comparisons show that exposure to radiation has a small risk relative to risks taken daily including driving a car, eating fatty foods, or smoking cigarettes. Some benefits from radiation include medical diagnosis and treatment, electricity, and results from scientific research.

Personnel Monitoring

Federal and State regulations require that individuals expected to receive more than 10% of the annual dose limits be monitored for occupational dose. At the University of Colorado, very few individuals are likely to exceed 10% of the limits. However, most technicians working in laboratories using radioactivity are monitored with a dosimeter in order to maintain a permanent record of the dose they may receive. Any dose received is recorded in units of mrem, and a record of the dose is maintained for the "life of the institution." Individuals using significant amounts of radionuclides that are likely to cause internal exposure are monitored periodically using bioassay techniques.

2. DOSIMETRY

Dosimeters are issued after proper training has been completed and a completed dosimetry application is received by Health Physics. Refer to Appendix K or our website <http://www.colorado.edu/radsafety> for a blank dosimetry application. By regulation, the University of Colorado is required to request exposure histories from all institutions at which individuals have worked in order to build a lifetime exposure history. Extremity

monitoring rings are issued to individuals working with greater than 37 MBq (1 mCi) of high energy radionuclides and at the discretion of the Radiation Safety Officer (RSO), following evaluation of experimental protocol. Extremity rings may be requested by an individual. A dosimeter may be canceled by returning it along with its holder to Health Physics with a note indicating cancellation is needed.

Whole Body

Individuals in laboratories using radionuclides other than ^3H or ^{14}C should apply for a whole body dosimeter. This includes individuals using sealed sources and radiation-producing machines.

Whole body dosimeters are designed to measure whole body dose to penetrating (x- and gamma ray) radiation as well as beta particle radiation. Consequently, the badge should be worn on the portion of the body most likely to receive a dose, usually on the front of the chest, anywhere between the neck and the waist. Care should be taken to prevent contamination of the badge. If contamination occurs, the badge should be immediately returned to Health Physics and a replacement will be issued for the remainder of the monitoring period. All dosimeters are assigned to specific individuals and are not transferable.

Extremity

Those individuals using **37 MBq (1 mCi) or more** of ^{32}P or other high-energy radionuclides are advised to be monitored with an extremity dosimeter, also known as a ring badge or TLD ring. Individuals performing beam alignments on radiation-producing machines should also be monitored with an extremity ring.

It is the responsibility of the Principal Investigator and/or experimenter to ensure that an extremity ring is worn when **37 MBq (1 mCi) or more** of ^{32}P or other high energy radionuclide is used during an experiment, or when completing beam alignments on x-ray machines. Extremity rings are designed to measure extremity dose. They should be worn on the hand most likely to receive a dose. Multiple sizes are available. The labeled section on the ring should be closest to the radiation source, usually facing into the palm.

Embryo/Fetus

If a woman becomes pregnant, it is her choice whether or not to “declare” her pregnancy. A Declared Pregnant Woman has a lower dose limit than a non-pregnant radiation worker due to the embryo/fetus limit. If the pregnancy is not “declared,” the woman continues working under the radiation worker dose limit. She may notify her supervisor and Health Physics that she is pregnant by completing a Fetal dosimeter application. The notification must be in writing in order to implement the lower dose limit. Refer to Appendix L for a blank Fetal dosimeter application. This application includes the signature of the worker affirming that she wishes to fall under the lower dose limit, as well as the estimated conception date. Individuals in the fetal dosimetry program will receive dose reports from Health Physics during the pregnancy.

3. BIOASSAY

Some radionuclides used at the University of Colorado present an increased risk of internal contamination. Use of unbound forms of radioiodine and ≥ 3700 MBq (100 mCi) of ^3H (tritium) requires bioassays to monitor internal dose. Prior to working with these radionuclides, each researcher must have “baseline” bioassays to ensure appropriate measurements following the experiments. Any internal dose received will be included in the individual’s dosimetry record. The Total Effective Dose Equivalent (sum of the internal and external doses to an individual) will be determined. If the Total Effective Dose Equivalent (TEDE) exceeds 0.05 Sv (5 rem), CDPHE must be notified within 24 hours. If the TEDE exceeds 0.25 Sv (25 rem), CDPHE must be notified immediately.

Anyone planning to work with unbound radioiodine or large amounts of ^3H (tritium) should contact Health Physics to schedule a baseline bioassay. The RSO may require that the experimental work be performed in the Health Physics facility. Follow-up bioassays will be scheduled, taking into account the biological half-life and anatomical target of the radionuclide involved.

Because most iodine in the body accumulates in the thyroid, internal contamination from radioiodine is measured by a non-invasive bioassay of the thyroid. The bioassay requires about 10 minutes.

Tritium (^3H) replaces stable hydrogen in the body water of the researcher; therefore urinalysis is necessary to measure the amount of internal (^3H) contamination.

Bioassays will be performed at the following intervals:

For Radioiodines – Within one week of using more than 1850 MBq (50 mCi) of I-125 or I-131 in a single operation (or within one week of using 37 MBq (10 mCi) in a non-contained form).

For Tritium – Within one week of using greater than 3700 MBq (100 mCi) of tritium in a single operation. For a continuous experiment using this amount of tritium, bioassays will be performed weekly (on the same day of each week, if possible) until it can be assessed that urine concentrations do not exceed this level in a calendar quarter. After that, bioassays may be taken monthly (on the same day of each month, if possible) as long as this level is maintained.

4. ENVIRONMENTAL MONITORING

As with all hazardous materials, radioactive materials may not be discharged into the sanitary sewer (down the drain) or released in any other way by researchers at the University of Colorado. In the event of a release, alert Health Physics **immediately at (303) 492-6523. Refer to the Mishaps and Emergencies chapter for additional information.**