http://www.ehs.washington.edu/manuals/rsmanual/6perexp.pdf

# 1 RADIATION DOSIMETRY

Radiation dosimetry concepts and units are not rigorously defined in this manual. Attempts are made to keep explanations in general terms. Regulatory descriptions and formulas are contained in the Washington Administrative Code (WAC) 246-220

## 1.1 Absorbed Dose (Dose)

Strictly, the term dose refers to the concept of absorbed dose. This is the amount of energy absorbed per unit mass of material. The traditional unit of absorbed dose is the rad (100 erg/gram), but this unit has been superseded by the International System (SI) unit called the gray (1 Gy = 1 Joule/Kg). Conversion between energy and mass units yields the relationship between gray and rad (1 Gy = 100 rad). Modern dosimetry employs some other concepts related to absorbed dose, yet modified to account for biological effects and partial body irradiation.

## 1.2 Dose Equivalent

Dose equivalent is a concept that attempts to account for the different biological consequences resulting from different types and energies of radiation at the same absorbed dose. For example, one gray of alpha particle radiation is more damaging to human tissue than one gray of x-rays. To apply this concept, the absorbed dose (in gray or rad) is multiplied by a quality factor (Q) related to the damaging ability of the radiation. A quality factor of 1 is given to x-rays, gamma rays, and beta particles. Alpha particles are given a quality factor of 20, and neutrons of unknown energy are given a quality factor of 10. The resulting units of dose equivalent are called the rem in traditional units and the sievert (Sv) in SI units. **One sievert is equal to 100 rem.**

## 1.3 Deep Dose Equivalent

The deep dose equivalent is a concept that applies to external whole body radiation. It is the dose equivalent at a tissue depth of 1 centimeter. This quantity is usually determined using a "whole body" dosimeter. It does not apply to weakly penetrating radiation such as alpha particles or low-energy electrons. Units of deep dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

## 1.4 Shallow Dose Equivalent

The shallow dose equivalent applies to external exposure of the skin of the whole body or the skin of an extremity. It is the dose equivalent just below the cornified layer of the skin at a tissue depth of 0.007 centimeter averaged over an area of 10 square centimeters. Units of shallow dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

### 1.5 Total Organ Dose Equivalent

The total organ dose equivalent is the sum of the deep dose equivalent from external radiation and the committed dose equivalent to the organ or tissue receiving the highest dose equivalent. Units of total organ dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

### 1.6 Total Effective Dose Equivalent

The total effective dose equivalent is the sum of the deep dose equivalent for external radiation and the committed effective dose equivalent for internal radiation. Units of total effective dose equivalent are the same as dose equivalent (rem in traditional units and sievert (Sv) in SI units).

## 2 DOSE LIMITS

Dose Limits are promulgated in the Washington Administrative Code (WAC 246-221). These limits were determined by national and international agencies after careful consideration of the best available information on the biological effects of radiation. The current prudent assumption is that any dose, no matter how small, might cause some degree of harm. Therefore, a radiation dose limit does not identify a line of demarcation between "safe" and "dangerous". Instead, current dose limits are set to assure that short-term effects of radiation are avoided, and the risk of long term effects (induction of cancer, genetic effects, and effects on the fetus) are held to an acceptable level.

### 2.1 Occupational Dose Limits for Adults

The annual limit for adult occupational dose is the more limiting of:
The total effective dose equivalent being equal to **0.05 Sv (5 rem);** or
The sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 0.5 Sv (50 rem). The annual limits to the lens of the eye, to the skin of the whole body, and to the skin of the extremities are: A lens dose equivalent of 0.15 Sv (15 rem); and
A shallow dose equivalent of 0.5 Sv (50 rem) to the skin of the whole body or to the skin of any extremity.
**Added: 2.5 mrem/h (25 uSv/h) for 40 hour week**

### 2.2 Occupational Dose Limits for Minors

Occupationally exposed individuals under the age of 18 must not receive a dose in excess of 10 percent of the annual occupational dose equivalent specified above for adults.

### 2.3 Occupational Dose Equivalent to an Embryo or Fetus

The dose equivalent to an embryo or fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, must not exceed 5 mSv (0.5 rem).

### 2.4 Non-Occupational Dose Limits

The total effective dose equivalent to individual members of the public from UW licensed or registered operations must not exceed **1 mSv (0.1 rem)** in a year. The dose in any unrestricted (public) area from external sources must not exceed **0.02 mSv (0.002 rem)** in any one hour.

## 3 DECLARED PREGNANT WORKER

If you are a radiation worker and are pregnant, you should know that you have the option of declaring your pregnancy in writing to the Radiation Safety Office to take advantage of voluntary limits for dose to the embryo/fetus.

## 4 ALARA PROGRAM

## 5 SEALED SOURCE LEAK TESTS

Some sealed sources are of such low activity that they do not require leak testing. However, most sealed sources require semi-annual or quarterly tests to assure integrity of the encapsulation. In addition to these tests, sealed sources must also be inventoried, typically every quarter. Sealed source leak tests and inventories are conducted by the Radiation Safety staff.

### 5.1 Sealed Beta/Gamma Emitters

Leak tests of sealed beta/gamma emitters generally consist of wiping the exterior of the source and counting the wipes with appropriate instrumentation. Leak test results are recorded on RSO Form 188 and are kept in the Radiation Safety Office for review by DOH inspectors.

### 5.2 Sealed Alpha Sources

Radioactive materials emitting non-penetrating radiation, such as alpha particles, are sometimes plated on the surface of a metal backing and minimally coated with a protective film. These sources are called sealed sources for regulatory purposes, but are not strictly sealed sources since the coating and underlying plating can be easily damaged. Radiation Safety staff takes wipe tests only on adjacent surfaces and does not touch the surface of calibrated alpha particle sources.