4. How Is Ionizing Radiation Measured?

Ionizing radiation is easy to detect, even in very small amounts. It can be measured using a number of different instruments. By measuring the amount of radiation present, people can identify sources of radiation and take the necessary steps to avoid or reduce exposure.

Ionizing radiation has the potential to damage living tissue. The extent of the damage depends, in part, on the type and amount of ionizing radiation that is absorbed by the tissue.

If no radiation energy is absorbed, no damage is done. Radiation detection is, therefore, an important part of protecting people and the environment from radiation.

This Fact Sheet defines radiation dose and the units in which dose is generally measured. It also describes some of the more common types of equipment used to detect radiation.

➤ Radiation Dose

As ionizing radiation passes through material, including living tissue, it interacts with atoms, transferring some of its energy during each interaction. The energy lost by the ionizing radiation is absorbed by the material or living tissue through which the radiation is traveling. It is this absorbed energy which can cause damage. Ionizing radiation that travels through material without interacting with any atom, without transferring energy, causes no damage.

To estimate how much damage ionizing radiation from a particular source might do, it is important to know the amount of energy the radiation carries. Two types of measurements of the radiation's energy are generally made: the exposure rate, which is the amount of radiation energy that reaches an object's surface in a given time period, and the absorbed dose, which is the amount of radiation energy that is actually absorbed by the material through which it passes. The absorbed dose is multiplied by a factor which takes into account the different biological effects of the various types of ionizing radiation. This converts the absorbed dose to the equivalent dose, which is of interest to most people, and it is the one that will be discussed in this Fact Sheet.

Source	Dose (per year)
Radon	200mrem
Naturally occurring radioactive material in the human body	40mrem
Medical x-rays	39mrem
Rocks and soil	28mrem
Cosmic radiation	27mrem
Nuclear medicine	14mrem
Consumer products	10mrem

Table 1. Average Annual Radiation Doses in U.S.A.

➤ Units in which Radiation is Measured

The term "dose" or "radiation dose" generally refers to the equivalent dose, which may be used for all kinds of ionizing radiations, not just x- or gamma rays. The equivalent dose is measured in rem or millirem. A millirem is one one-thousandth of a rem. In other words, one thousand millirem equal one rem (1000 millirem = 1 rem). Millirem is often abbreviated as mrem.

What radiation dose does the typical person receive? Several sources of radiation and the dose that each source gives to the average American each year are listed in Table 1.

Federal regulations require that a low-level radioactive waste disposal facility be de-

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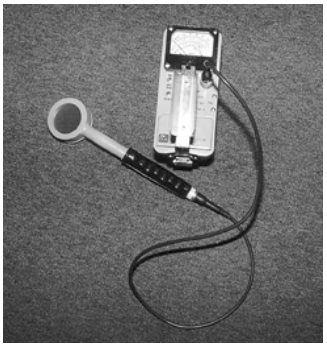
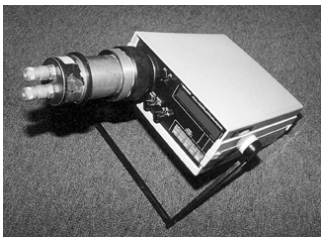
Figure 1. Radiation Monitors

Personal Dosimeters



Hand-Held Detector



Continuous Sampling Monitor

signed, operated, and controlled after closure so that no member of the public receives an annual dose greater than 25 mrem. No existing facility, operating or closed, has resulted in an annual dose of more than 3 mrem to any member of the public.

Federal radiation safety regulations allow a worker in a nuclear facility to receive up to 5 rem (5,000 mrem) each year.

The radiation dose divided by the time over which it is delivered is called the dose rate. The effect of a particular radiation dose on living tissue may depend on the dose rate. It is generally believed that radiation doses delivered at low dose rates are less damaging than the same dose delivered at a high dose rate (see, for example, National Research Council report "Biological Effects of Ionizing Radiation V").

➤ Devices for Measuring Radiation

Many different devices are used to measure radiation under a wide range of conditions. Three categories of devices are personal dosimeters, hand-held detectors, and continuous sampling monitors. (See Figure 1)

People working in or visiting nuclear facilities usually wear personal dosimeters on their clothing. These devices measure the radiation dose a person receives while in the facility. A film badge is an example of a personal dosimeter.

Hand-held detectors are used to measure the exposure rate from a specific object. The exposure rate from a package of radioactive waste or a piece of granite can be measured with a hand-held detector such as a Geiger counter.

Continuous sampling monitors can be set up to take samples of air or water in and around a low-level radioactive waste disposal facility. Several different types of monitors are used. With one type, the samples are collected and evaluated periodically to ensure the concentration of radioactive material in the air or water is within limits set by federal and state regulations. Another type of continuous monitor is designed to emit a signal when the amount of radiation present would give a dose higher than a specified limit.

➤ For More Information

If you want to read more about measuring radiation, some of the references listed below may be helpful.

- Eric J. Hall, *Radiation and Life*, Fourth Edition, J. Lippincott Co,, New York, 1994.
- Fred A. Mettler, Jr. M.D. and Arthur C. Upton, M.D., *Medical Effects of Ionizing Radiation*, Grune & Stratton, Inc., Orlando, Florida,1995.
- Jacob Schapiro, *Radiation Protection*, Harvard University Press, 1990.
- National Research Council, *Biological Effects of Ionizing Radiation*, 1993.

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