6. How Are People and the Environment Protected From Ionizing Radiation?

We are continuously exposed to background radiation from such sources as cosmic rays from space, radon from the soil, and naturally occurring radioactive materials within our bodies. It is not possible to protect people from sources of background radiation distributed throughout the environment.

However, when a source of radiation is concentrated and confined in a small area, the radiation dose people receive from that source can be limited by the use of carefully planned structures and procedures. The three factors that determine the size of the radiation dose received are **time, distance,** and **shielding**.

This Fact Sheet explains how these three physical factors affect the dose, with emphasis on a discussion of shielding, including shielding for low-level radioactive waste and the regulations governing radioactive waste, which utilize these physical factors. First, a brief review of **ionizing radiation** and its effects is presented.

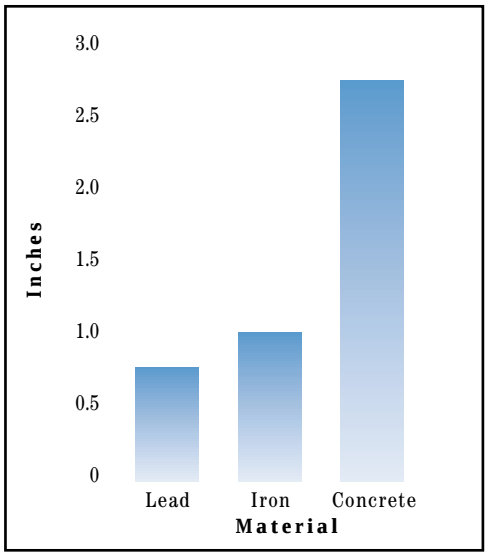

Figure 1. **Shielding Materials and Their Half-Thicknesses for Gamma Radiation**

Ionizing Radiation

When radioactive atoms decay, their extra energy is released in the form of ionizing radiation. Three types of ionizing radiation are alpha particles, beta particles, and gamma rays. They are called ionizing radiation because as they move through matter, they knock electrons out of their orbits and form ions. The ionizing radiation uses up some of its energy each time it creates an ion. Eventually, the radiation uses all of its energy and can no longer cause any damage. (For a more detailed discussion of ionizing radiation, see the Fact Sheet "What is Ionizing Radiation?")

Effects of Ionizing Radiation

Ionizing radiation can affect living things by *altering* the cells that make up the living organism. Cells are made up of molecules. Cell damage is caused by interaction of radiation with these molecules, forming ions.

Radiation effects on a cell are random. That is, the same type and amount of radiation could strike the same cell many times and have a different effect, including no effect, each time. However, in general, the more radiation that strikes the cell, the greater the chance that there will be an effect.

Factors That Affect Radiation Doses

Methods of protecting people from radiation focus on reducing the amount of radiation that reaches us. Regulations and procedures have been developed and implemented to limit radiation dose by regulating the use, storage, transport, and disposal of radioactive material by controlling time, distance, and shielding.

➤ Time

The dose of radiation a person receives depends on how long the person is near a

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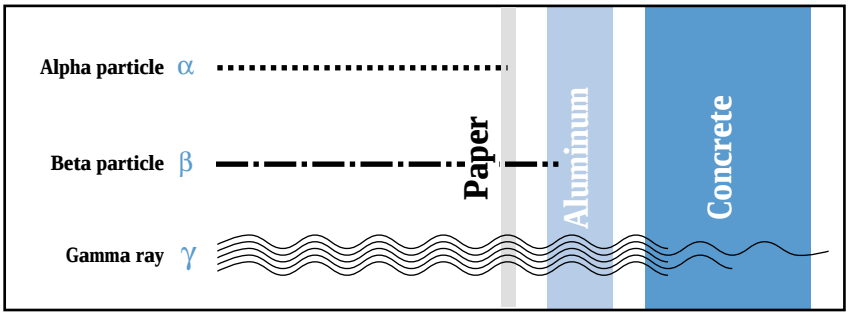

Figure 2. **Types of Radiation and Shielding**

radiation source. The shorter the time spent near the source, the smaller the dose. Radiation protection procedures are designed to keep the time people spend near a source of radiation as short as possible.

➤ Distance

Similarly, the radiation dose a person receives depends strongly on how close the person is to a source. The greater the distance between the person and a source of radiation, the smaller the dose. For example, a barrel of waste might give a dose of 20 millirems per hour at a distance of 1 foot from the surface. At 10 feet away the dose rate might be about 1 millirem per hour.

➤ Shielding

One way to minimize the amount of radiation that reaches people is to put some material, called shielding, between them and a radiation source. When radiation strikes the shielding, it begins to create ions in the shield. Each time an ion is created, the radiation loses some of its energy. If the shielding is thick enough, energy will be used up before it gets through the shielding.

Any material provides some shielding. Common shielding materials are iron, concrete, lead, and soil. Scientists measure the shielding ability of a material by determining the thickness of the material required to absorb half of the radiation from a given source. This thickness of the material is called the **half-thickness**. Radiation that has passed through one half-thickness will be reduced by half again if it passes through another half-thickness. The half-thickness depends on both the characteristics of the shielding material and type and energy of the radiation being emitted. Some common shielding materials and their half-thicknesses for high energy gamma rays are shown in Figure 1.

Shielding and Low-Level Radioactive Waste

The three types of ionizing radiation commonly released from low-level radioactive waste are

- alpha particles, which consist of two protons and two neutrons and are positively charged. They can be stopped, or shielded, by a sheet of paper or the outer layer of skin.
- beta particles,which are high-speed electrons. More penetrating than alpha particles, they can pass through an inch of water or human flesh. Beta particles can be effectively shielded with a sheet of aluminum 1/25 of an inch thick.
- Gamma rays, which are similar to x-rays, can pass through the human body like x-rays. Dense materials such as concrete and lead can provide shielding from gamma radiation.

Shielding for alpha, beta, and gamma radiation is illustrated in Figure 2.

Low-level radioactive waste is shielded by various methods at the generator site, during transportation, and at the disposal facility.

At the generator site, low-level radioactive waste is typically stored in closed containers designed to contain the waste and provide shielding. Common containers include steel and polyethylene drums. Additional shielding may be provided by the building in which the waste is stored.

The kinds of shipping containers used for transportation of low-level radioactive waste depend upon the type and concentration of radionuclides in the waste. Regulations governing the transportation of low-level

waste set limits on the level of radiation allowed at the surface of the container. Limits are also set on the radiation level allowed at the outer surface of the truck. Additional shielding, usually in the form of steel or lead sheets, is attached to the inside walls of the truck, if needed, to meet the vehicle outer surface radiation requirements.

Shielding ionizing radiation at low-level radioactive waste disposal facilities is accomplished in various ways, depending on the type of facility. Waste containers, concrete-walled structures, and mounds of soil over these buildings are typically used for shielding at such a facility.

➤ For More Information

If you would like to read more about radiation protection, some of the references listed below may be helpful.

- Eric J. Hall, *Radiation and Life*, 4th Edition, J.P. Lippincott Co., New York, 1994.
- Raymond L. Murray, *Understanding Radioactive Waste*, Battelle Press, Columbus, Ohio, Fourth Edition, 1994.
- Other Fact Sheets:

  #7 What Are the Health Effects of Ionizing Radiation?

  #5 How Do Radioactive Materials Move Through the Environment to People?

  #2 What Is Ionizing Radiation?

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