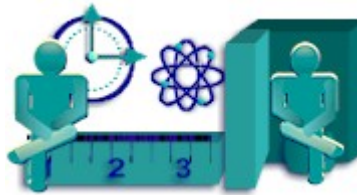


## Radiation Protection Basics

### Radiation Protection Basics

Three basic concepts apply to all types of ionizing radiation. When we develop regulations or standards that limit how much radiation a person can receive in a particular situation, we consider how these concepts might affect a person's exposure.

#### Basic Concepts of Radiation Protection



TIME DISTANCE SHIELDING

#### Time

The amount of radiation exposure increases and decreases with the time people spend near the source of radiation.

In general, we think of the exposure time as how long a person is near radioactive material. It's easy to understand how to minimize the time for external (direct) exposure. Gamma and x-rays are the primary concern for external exposure.

However, if radioactive material gets inside your body, you can't move away from it. You have to wait until it decays or until your body can eliminate it. When this happens, the biological half-life of the radionuclide controls the time of exposure. Biological half-life is the amount of time it takes the body to eliminate one half of the radionuclide initially present. Alpha and beta particles are the main concern for internal exposure.

#### How does EPA use the concept of time in radiation protection?

When we set a radiation standard that assumes an exposure over a certain period, we are applying the concept of time. For example, we often express exposures in terms of a committed dose. A committed dose is one that accounts for continuing exposures over long periods of time (such as 30, 50, or 70 years). It refers to the exposure received from radioactive material that enters and remains in the body for many years.

When we assess the potential for exposure in a situation, we consider the amount of time a person is likely to spend in the area of contamination. For example, in assessing the potential exposure from radon in a home, we estimate how much time people are likely to spend in the basement.

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## **Distance**

The farther away people are from a radiation source, the less their exposure.

How close to a source of radiation can you be without getting a high exposure? It depends on the energy of the radiation and the size (or activity) of the source. Distance is a prime concern when dealing with gamma rays, because they can travel long distances. Alpha and beta particles don't have enough energy to travel very far.

As a rule, if you double the distance, you reduce the exposure by a factor of four. Halving the distance, increases the exposure by a factor of four.

### **Why does exposure change more rapidly than the distance?**

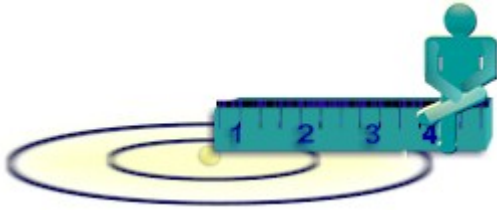
The area of the circle depends on the distance from the center to the edge of the circle (radius). It is proportional to the square of the radius. As a result, if the radius doubles, the area increases four times.

Think of the radiation source as a bare light bulb. The bulb gives off light equally in every direction, in a circle. The energy from the light is distributed evenly over the whole area of the circle. When the radius doubles, the radiation is spread out over four times as much area, so the dose is only one fourth as much. (In addition, as the distance from the source increases so does the likelihood that some gamma rays will lose their energy.

### **Exposure at 2 feet**



### Exposure at 4 feet



The exposure of an individual sitting 4 feet from a radiation source will be 1/4 the exposure of an individual sitting 2 feet from the same source

### How does EPA use the concept of distance in radiation protection?

We also consider distance in analyzing potential exposures from a source. If a person is at a contaminated site, or working around radioactive material, we assess how the exposures vary if the person is closer to, or farther away from, the source of radiation.

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### Shielding

The greater the shielding around a radiation source, the smaller the exposure.

Shielding simply means having something that will absorb radiation between you and the source of the radiation (but using another person to absorb the radiation doesn't count as shielding). The amount of shielding required to protect against different kinds of radiation depends on how much energy they have.

$\alpha$   
(Alpha) A thin piece of light material, such as paper, or even the dead cells in the outer layer of human skin provides adequate shielding because alpha particles can't penetrate it. However, living tissue inside body, offers no protection against inhaled or ingested alpha emitters.

$\beta$   
(Beta) Additional covering, for example heavy clothing, is necessary to protect against beta-emitters. Some beta particles can penetrate and burn the skin.

$\gamma$   
(Gamma) Thick, dense shielding, such as lead, is necessary to protect against gamma rays. The higher the energy of the gamma ray, the thicker the lead must be. X-rays pose a similar challenge, so x-ray technicians often give patients receiving medical or dental X-rays a lead apron to cover other parts of their body.

### **How does EPA use the concept of shielding in radiation protection?**

We take into account the type of shielding that might be provided by soil when we assess sites that have been contaminated or used for disposal of radioactive material. We also account for the shielding provided by buildings for a person working or living at a site that has been cleaned up.

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### **What kinds of health effects does exposure to radiation cause?**

In general, the amount and duration of radiation exposure affects the severity or type of health effect. There are two broad categories of health effects: stochastic and non-stochastic.

#### **Stochastic Health Effects**

Stochastic effects are associated with long-term, low-level (chronic) exposure to radiation. ("Stochastic" refers to the likelihood that something will happen.) Increased levels of exposure make these health effects more likely to occur, but do not influence the type or severity of the effect.

Cancer is considered by most people the primary health effect from radiation exposure. Simply put, cancer is the uncontrolled growth of cells. Ordinarily, natural processes control the rate at which cells grow and replace themselves. They also control the body's processes for repairing or replacing damaged tissue. Damage occurring at the cellular or molecular level, can disrupt the control processes, permitting the uncontrolled growth of cells--cancer. This is why ionizing radiation's ability to break chemical bonds in atoms and molecules makes it such a potent carcinogen.

Other stochastic effects also occur. Radiation can cause changes in DNA, the "blueprints" that ensure cell repair and replacement produces a perfect copy of the original cell. Changes in DNA are called mutations.

Sometimes the body fails to repair these mutations or even creates mutations during repair. The mutations can be teratogenic or genetic. Teratogenic mutations are caused by exposure

of the fetus in the uterus and affect only the individual who was exposed. Genetic mutations are passed on to offspring.

### Non-Stochastic Health Effects

Non-stochastic effects appear in cases of exposure to high levels of radiation, and become more severe as the exposure increases. Short-term, high-level exposure is referred to as 'acute' exposure.

Many non-cancerous health effects of radiation are non-stochastic. Unlike cancer, health effects from 'acute' exposure to radiation usually appear quickly. Acute health effects include burns and radiation sickness. Radiation sickness is also called 'radiation poisoning.' It can cause premature aging or even death. If the dose is fatal, death usually occurs within two months. The symptoms of radiation sickness include: nausea, weakness, hair loss, skin burns or diminished organ function.

Medical patients receiving radiation treatments often experience acute effects, because they are receiving relatively high "bursts" of radiation during treatment.

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<b>Exposure (rem)</b>	<b>Health Effect</b>	<b>Time to Onset (without treatment)</b>
5-10	changes in blood chemistry	
50	nausea	hours
55	fatigue	
70	vomiting	
75	hair loss	2-3 weeks
90	diarrhea	
100	hemorrhage	
400	possible death	within 2 months
1,000	destruction of intestinal lining	
	internal bleeding	
	and death	1-2 weeks
2,000	damage to central nervous system	
	loss of consciousness;	minutes
	and death	hours to days

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**Aren't children more sensitive to radiation than adults?**

Yes, because children are growing more rapidly, there are more cells dividing and a greater opportunity for radiation to disrupt the process. EPA's radiation protection standards take into account the differences in the sensitivity due to age and gender. Fetuses are also highly sensitive to radiation. The resulting effects depend on which systems are developing at the time of exposure.

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