Radiation Protection



# Exposure Pathways

**Health Effects**

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Each of the different routes, or pathways, by which people can be exposed to radiation result in exposure to different parts of the body. Health physicists must analyze the potential for and effects of exposure via each of the three basic pathways, inhalation, ingestion, and direct exposure, when calculating exposures or estimating the effects of exposures.



## Inhalation

Exposure by the inhalation pathway occurs when people breathe radioactive materials into the lungs. The chief concerns are radioactively contaminated dust, smoke, or gaseous radionuclides such as radon.

### What happens to inhaled radioactive materials?

Radioactive particles can lodge in the lungs and remain for a long time. As long as it remains and continues to decay, the exposure continues. For radionuclides that decay slowly, the exposure continues over a very long time. Inhalation is of most concern for radionuclides that are alpha or beta particle emitters. Alpha and beta particles can transfer large amounts of energy to surrounding tissue, damaging DNA or other cellular material. This damage can eventually lead to cancer or other diseases and mutations.

Health Effects

### How does EPA protect people from inhalation exposure?

EPA first determines the risk for inhalation from various sources of radionuclides and then determines protective emission limits. In estimating the risk and effects of exposure for a given situation, EPA's health physicists consider several factors:

- potential for soil to be disturbed and suspended into the air
- potential for radon generation
- presence of other volatile radionuclides (e.g., tritium, carbon-14)

industrial processes, such as incineration, that could release radionuclides to the air or generate residues, such as ash
potential for mishandling radioactive material

Protecting People and the Environment
Laws We Use: Clean Air Act
EPA's Radon Protection Program

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## Ingestion

Exposure by the ingestion pathway occurs when someone swallows radioactive materials. Alpha and beta emitting radionuclides are of most concern for ingested radioactive materials. They release large amounts of energy directly to tissue, causing DNA and other cell damage.

### What happens to ingested radioactive materials?

Ingested radionuclides can expose the entire digestive system. Some radionuclides can also be absorbed and expose the kidneys and other organs, as well as the bones. Radionuclides that are eliminated by the body fairly quickly are of limited concern. These radionuclides have a short biological half-life.

Health Effects

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### How does EPA protect people from ingestion exposure?

EPA first considers the potential for radionuclides from various sources to enter water, the food chain, or get into peoples' mouths in day to day activities. We also look at the percentage of peoples' diet--food and drink--that comes from radioactive sources. Factors that can lead to ingestion include the following:

radioactively contaminated drinking water, for example, polluted ground water
working closely with radioactively contaminated soil, for example farming
locally grown food plants that take up certain soil radioactivity
use of radioactively contaminated water to irrigate crops
local livestock operations, when radionuclides that accumulate in animal tissue are present
consumption of fish with radioactivity from local bodies of water
people bathing, swimming, or otherwise using radioactive water sources

EPA then takes appropriate measures to reduce the potential for exposure through ingestion of radioactivity. The measures often include setting limits on emissions from a source, radioactive contaminant levels in water resources, consumption of radioactivity from locally grown food.

Radionuclides in Drinking Water

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## Direct (External) Exposure

The third pathway of concern is direct or external exposure from radioactive material. The concern about exposure to different kinds of radiation varies:

Limited concern about alpha particles. They cannot penetrate the outer layer of skin, but if you have any open wounds you may be at risk.

Greater concern about beta particles. They can burn the skin in some cases, or damage eyes.
Greatest concern is about gamma radiation. Different radionuclides emit gamma rays of different strength, but gamma rays can travel long distances and penetrate entirely through the body.



Gamma rays can be slowed by dense material (shielding), such as lead, and can be stopped if the material is thick enough. Examples of shielding are containers; protective clothing, such as a lead apron; and soil covering buried radioactive materials.

**How does EPA protect people from direct exposure?**

We rely on the fundamental radiation protection principles of time, distance, and shielding to protect people who work directly with radioactive materials. In assessing potential direct exposure, we ask three basic questions:

How long is the person exposed (time)?
How close is the person to the source of exposure (distance)?
Is there something between the person and the source of exposure that can absorb some of the radiation (shielding)?

The amount of exposure also depends on how the source is arranged. For example, whether the source is concentrated in one place, or more evenly distributed.

Radiation Protection Basics

Understanding Radiation in Your Life, Your World

Programs · Topics · References