Introduction to Radiation

CT007-F Companion Booklet

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Contents

1 Introduction

This booklet is intended to be a very brief introduction to radiation. It is by no means complete. There are many good learning resources (and also much nonsense) on the internet.

The US Department of Energy/Transportation Emergency Preparedness Program (TEPP) has some very good videos. Please search YouTube for:

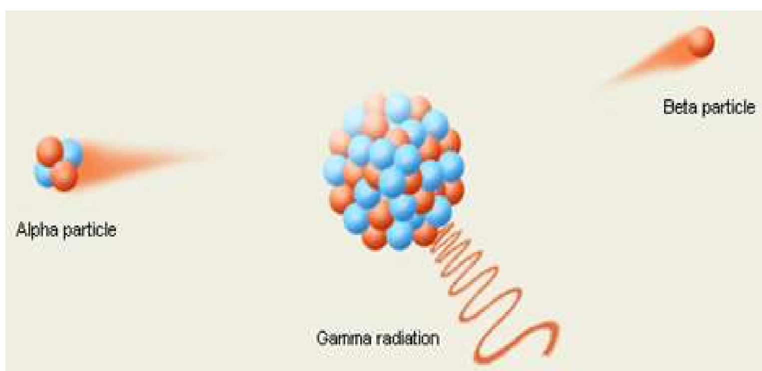
“TEPP Radiological Basics”
“TEPP 4 Types of Ionizing Radiation”
“TEPP Time Distance Shielding”
“TEPP Biologic Effects of Radiation”

The dose limits and guidance given in this booklet were collected from various international sources. Radiation limits and guidance may differ between countries.

2 What is Radiation?

Radiation is energy that is emitted from unstable atoms.

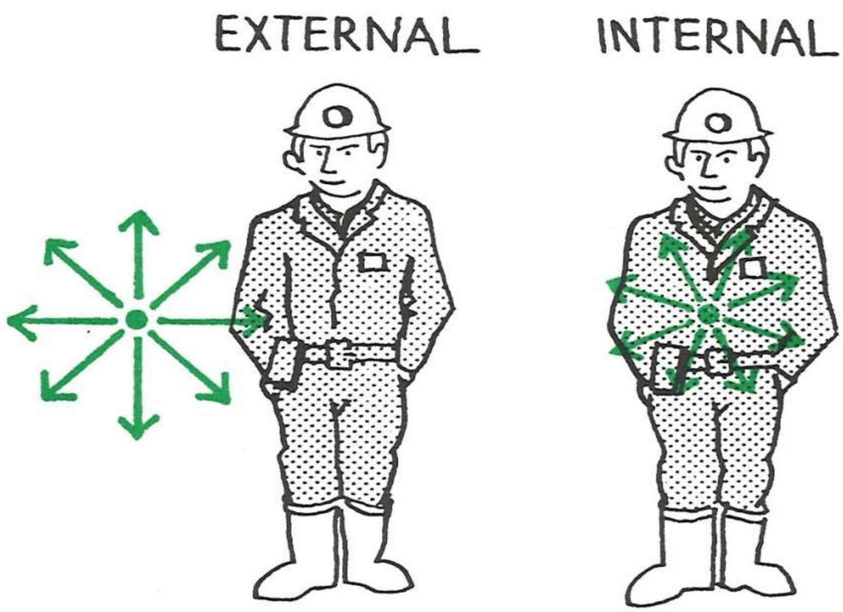
Radiation may take the form of physical sub-atomic particles or electromagnetic waves.



3 Exposure Pathways

Exposure to external gamma radiation, emitted by a radioactive source near your body, will travel through the air and impact your body. The exposure stops once you are far enough away from the source of radiation.

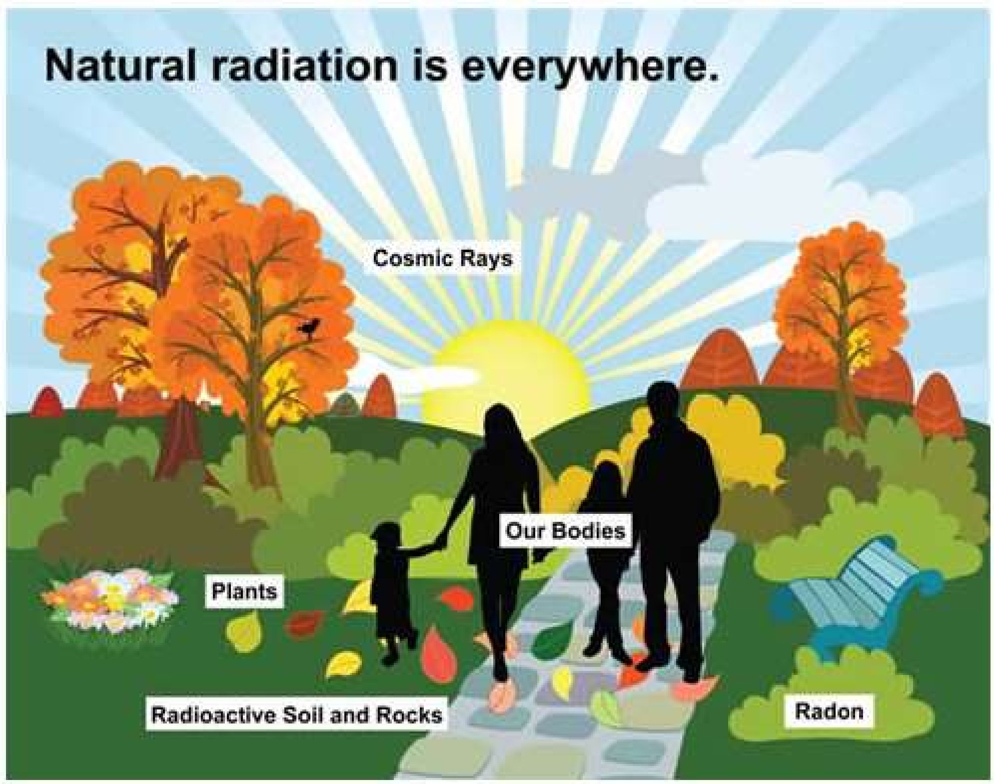
Internal radiation, on the other hand, will continue to expose you to the radiation that is inside you until the radioactive material is removed. Radioactive material can enter your body by ingestion or inhalation.



4 Natural Background Radiation

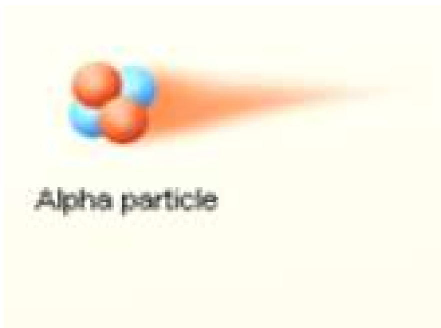
We are exposed to radiation daily.
Sources of natural radiation include:

- Cosmic rays
- Terrestrial, e.g. Uranium and Thorium in rock and soil
- Inhalation, e.g. Radon gas
- Ingestion, e.g. Potassium (K-40) and Carbon (C-14)



5 Alpha, Beta and Gamma Radiation

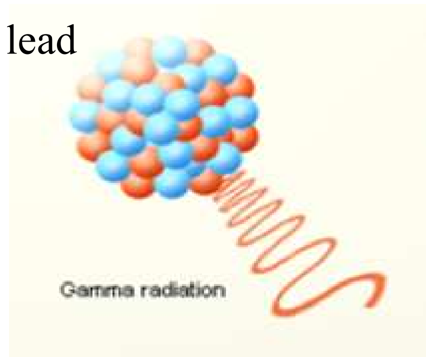
Alpha particles are short ranged and cannot travel more than a few centimeters in the air. They are easily stopped externally by our skin but are an internal hazard when ingested. Alpha radiation is the most dangerous type of radiation when ingested.

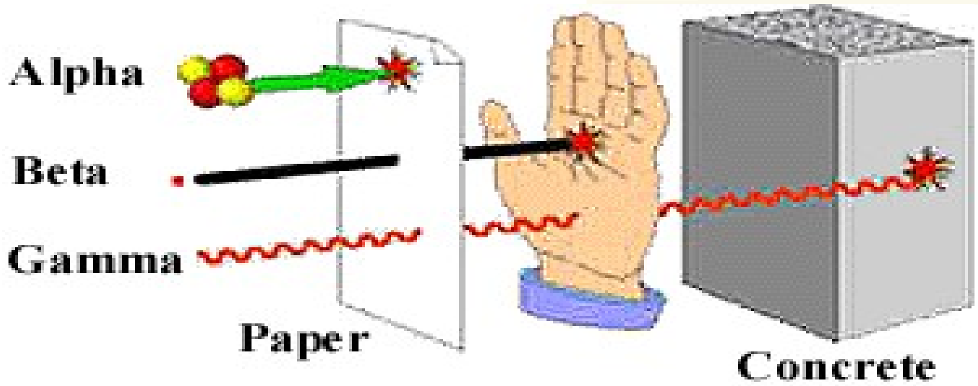


Beta particles have an intermediate range and will travel up to a few meters in air. They can be blocked by safety glasses or heavy gloves.

Gamma/X-rays are electromagnetic waves and are deeply penetrating rays. These types of rays require heavy shielding to be blocked

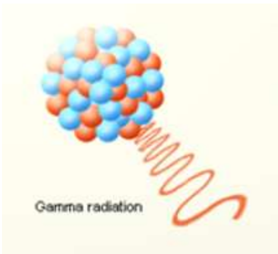
e.g. concrete walls, thick steel or lead





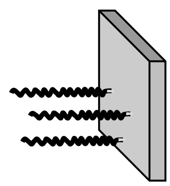
6 Reducing Your Radiation Exposure

a) External Gamma Exposure



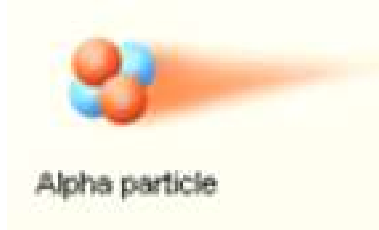
To control external radiation you can do the following:

- Minimize time spent near the source.
- Distance yourself from the source when possible.
- Use shielding between yourself and the source when possible (examples: lead, water, concrete, steel).



b) Internal Exposure

Internal exposure is radioactive material inhaled or ingested and is found inside the body.

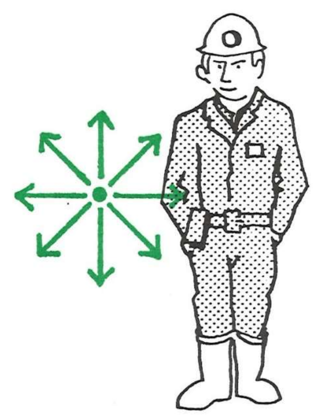


You can control internal exposure by doing the following:

- Use respiratory protection and/or stay upwind.
- Wear personal protective equipment (e.g. disposable suit, safety glasses, gloves, shoe covers) when available.

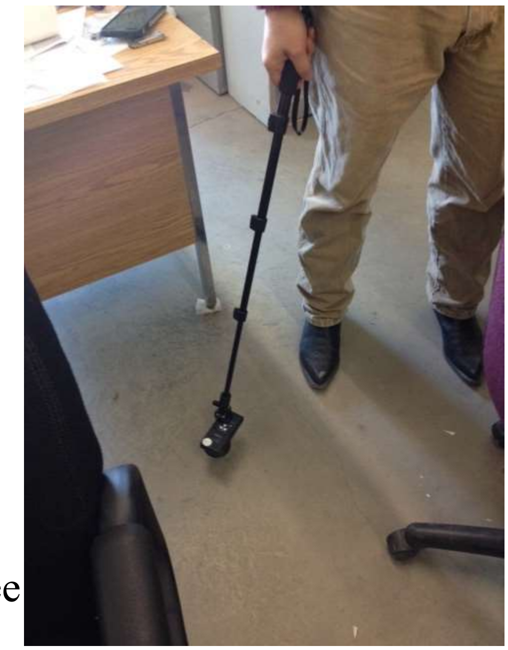
The easiest way to reduce ingestion of radioactive material is to check hands, clothes, tools etc. for radioactive contamination and clean up.

Monitor for the spread of contamination.



7 Radiation Units

The Sievert (Sv) measures the amount of radiation dose received. The rem is an older unit. 100 rem = 1Sv. The milisievert (mSv) and microSievert (µSv) are used to measure smaller amounts. 1 Sv = 1000 mSv = 1 000 000 µSv.



The Becquerel (Bq) measures the number of radioactive disintegrations/second.

The Count Per Minute (CPM) measures instrument response to radiation. This is used for measuring contamination.

Typically, an instrument with a larger sensor will see more CPM than a smaller sensor, given the same amount of contamination.

8 Dose and Dose Rate

Dose = dose rate x time

Example: Stay 1 hour in a gamma field of 1 mSv/hr

Dose = 1mSv/hr x 1 hour = 1 mSv (1000µSv)

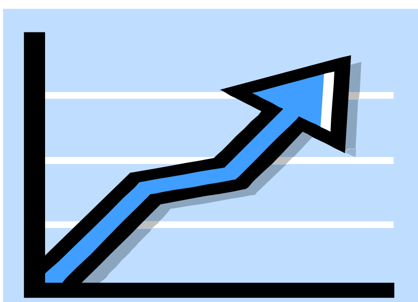
You can get the public dose limit of 1 mSv per year in 1 hour at 1 mSv/hr or in 1000 hours at 1 µSv/hr.

9 Radiation Risks

The primary health risk associated with chronic low-level exposure to ionizing radiation is cancer. The health risks of chronic low-level exposure are delayed (often decades after exposure).

The health risk is proportional to the radiation dose received. This means that the greater the exposure, the greater the risk.

Acute risks are associated with high short-term radiation exposure.



Dose	Limit or Health Effect
More than 5,000 mSv	Dose which may lead to death when received all at once
1,000 mSv	Dose which may cause symptoms of radiation sickness (e.g. tiredness and nausea) if received within 24 hours
100 mSv (100,000 μSv)	**Lowest acute dose known to cause cancer**
30-100 mSv	Radiation dose from a full body computed axial tomography (CAT) scan
50 mSv	Annual radiation dose limit for nuclear energy workers
1.8 mSv	Average annual Canadian background dose
1 mSv	Annual public radiation dose limit
0.1-0.12 mSv	Dose from lung X-ray

The table shows that below 100 mSv, any increase in cancer rates is too small to be observed in epidemiological studies. For radiation protection purposes, it is <u>assumed</u> that any exposure to radiation increases the risk of cancer slightly.

There is considerable debate about whether this is the correct model. Some people claim that the data is more consistent with a threshold, below which there actually is no effect, and still others claim that the data is consistent with a beneficial effect of low dose radiation. This is called radiation hormesis.

10 Dose and Dose Rate Guidance

Dose or Dose Rate	Limit
Unlimited mSv or mSv/hr	Limit for Life Saving Activities (Volunteer Basis)
1,000 mSv/hr (1,000,000 μSv/hr)	Turn-back dose rate Emergency Situation
250 mSv	Maximum Permissible Dose Emergency Situation
50 mSv	Annual radiation dose limit for nuclear energy workers
1 mSv	Annual public radiation dose limit
1 mSv/hr	Turn-back dose rate Routine Situation (non-emergency)
0.5 mSv	Maximum Permissible Dose Routine Situation (non-emergency)

11 Radiation Measuring Instruments

Most of the inexpensive radiation detectors only measure external gamma (and maybe some energetic beta) radiation. These detectors typically consist of a thick walled Geiger tube inside the instrument. Only penetrating radiation, like gamma, can get inside the Geiger tube and be counted. These instruments are not suitable for measuring alpha/beta contamination.

Other instruments use a Geiger tube that has a small thin window at the end with a hole in the instrument case, which exposes that window. Alpha and beta radiation can be detected through this window. However, since this window is small compared to the overall size of the Geiger tube, the instrument's response to background gamma radiation swamps any alpha/beta contamination readings, unless there is a lot of alpha/beta.

Instruments that are suitable for measuring low levels of alpha/beta contamination, as well as gamma radiation, include the CT007-F and instruments built around a 'pancake' type Geiger tube.

12 Checking Your Instrument

There are many materials available that are radioactive and can be used as check sources.

There are two small uranium glass beads included with your CT007-F. The uranium (and decay products) contained in the beads emit alpha, beta and gamma radiation. Most of the counts registered by the CT007-F on the beads will be from beta radiation. Very few of the alpha particles will make it out of the glass and most of the gamma rays will pass through the detector without interacting. On contact with one bead (with the slider open), the detector should read around 100 CPM.

Another easy to obtain source is potassium chloride “sodium free” salt substitute. This is available in most large grocery stores. Pour some of that into a Ziplock bag and measure it with your detector (with beta shield open). The response of your detector should be several times background. Potassium (K-40) emits both gamma and beta radiation and both types of radiation will pass through the bag (alpha would be stopped by the bag). The amount of gamma radiation from a small amount of salt substitute is difficult to see above normal background radiation. The beta radiation, on the other hand, is easily measurable above background with an instrument like the CT007-F.