IONIZING RADIATION EXPOSURE-

Monitoring and Dosimetry

APPENDIX II

EXAMPLES OF IONIZING RADIATION

Alpha Particles

Alpha particles are energetic, positively charged particles (helium nuclei) that rapidly lose energy when passing through matter. They are commonly emitted in the radioactive decay of the heaviest radioactive elements such as uranium and radium as well as by some manmade elements. Alpha particles lose energy rapidly in matter and do not penetrate very far; however, they can cause damage over their short path through tissue. These particles are usually completely absorbed by the outer dead layer of the human skin and, so, alpha emitting radioisotopes are not a hazard outside the body. However, they can be very harmful if they are ingested or inhaled. Alpha particles can be stopped completely by a sheet of paper.

Beta Particles

Beta particles are fast moving, positively or negatively charged electrons emitted from the nucleus during radioactive decay. Humans are exposed to beta particles from manmade and natural sources such as tritium, carbon-14, and strontium-90. Beta particles are more penetrating than alpha particles, but are less damaging over equally traveled distances. Some beta particles are capable of penetrating the skin and causing radiation damage; however, as with alpha emitters, beta emitters are generally more hazardous when they are inhaled or ingested. Beta particles travel appreciable distances in air, but can be reduced or stopped by a layer of clothing or by a few millimeters of a substance such as aluminum.

Gamma Rays

Like visible light and X-rays, gamma rays are weightless packets of energy called photons. Gamma rays often accompany the emission of alpha or beta particles from a nucleus. They have neither a charge nor a mass and are very penetrating. One source of gamma rays in the environment is naturally occurring potassium-40. Manmade sources include plutonium-239 and cesium-137. Gamma rays can easily pass completely through the human body or be absorbed by tissue, thus constituting a radiation hazard for the entire body. Several feet of concrete or a few inches of lead may be required to stop the more energetic gamma rays.

Major Uses of Radioisotopes in the United States

RADIOISOTOPE	HALF-LIFE	RADIOACTIVE EMISSION	USE
Americum-241	433 y	α γ	▪ Smoke detectors ▪ Measure levels of toxic lead ▪ Ensure uniform thickness in rolling process (i.e. steel and paper production) ▪ Determine where oil wells should be drilled
Cadmium-109	462 d	γ	▪ Analyze metal alloys
Calcium-47	4.5 d	β γ	▪ Biomedical research
Californium-252	2.6 y	α γ	▪ Inspect airline luggage ▪ Gauge the moisture content of soil ▪ Measure the moisture of materials stored in soils
Carbon-14	5715 y	β	▪ Biological research, agriculture, pollution control
Cesium-137	30 y	β γ	▪ Treat cancerous tumors ▪ Measure correct patient dosages ▪ Measure and control the liquid flow in oil pipelines
Chromium-51	27.7 d	γ	▪ Research in red blood cell survival
Cobalt-57	272 d	γ	▪ Medical diagnostic
Cobalt-60	5.3 y	β γ	▪ Sterilize surgical instruments ▪ Improve the safety and reliability fuel oil burners ▪ Cancer treatment, food irradiation, gauges, and radiography
Copper-67	2.6 d	β γ	▪ Cancer treatment
Curium-244	18 y	α γ	▪ Mining and drilling to analyze material excavated from pits
Gallium-67	3.3 d	γ	▪ Medical diagnosis
Iodine-123	13 h	γ	▪ Diagnose metabolic disorders
Iodine-125	59 d	γ	▪ Biomedical research ▪ Diagnose metabolic disorders
Iodine-129	15,700,000 y	β γ	▪ Check radioactivity counters
Iodine-131	8 d	β γ	▪ Treat thyroid disorders
Iridium-192	74 d	β γ	▪ Test integrity of pipeline welds, boilers and aircraft parts ▪ Brachytherapy/tumor irradiation
Iron-55	2.7 y	α γ	▪ Analyze electroplating solutions ▪ Detect the presence of sulphur in the air ▪ Metabolism research
Krypton-85	10.8 y	β γ	▪ Indicator lights in appliances ▪ Gauge the thickness of misc. materials ▪ Measure dust and pollutant levels
Nickel-63	100 y	β	▪ Detect explosives ▪ Voltage regulators and current surge protectors ▪ Electron capture detectors for gas chromatographs

Major Uses of Radioisotopes in the United States (con't)

RADIOISOTOPE	HALF-LIFE	RADIOACTIVE EMISSION	USE
Phosporus-32	14 d	β	▪ Molecular biology and genetics research
Phosphorus-33	25 d	β	▪ Molecular biology and genetics research
Plutonium-238	88 y	α γ	▪ Powered NASA spacecraft
Polonium-210	138 d	α γ	▪ Reduce static charge in materials (photographic film)
Promethium-147	13.4 m	β γ	▪ Electric thermostats ▪ Gauge the thickness of misc. materials
Radium-226	1599 y	α γ	▪ Makes lighting rods more effective
Selenium-75	120 d	γ	▪ Protein studies
Sodium-24	15 h	β γ	▪ Locate leaks in industrial pipe lines ▪ Oil well studies
Strontium-85	65 d	γ	▪ Study bone formation and metabolism
Sulphur-35	87 d	β	▪ Survey meters ▪ Cigarette manufacturing sensors ▪ Medical treatment
Technetium-99m	213,000 y	β γ	▪ Genetics and molecular biology research ▪ Radioactive pharmaceutical (nuclear medicine) ▪ Medical imaging (x-ray)
Thallium-201	3 d	γ	▪ Nuclear medicine
Thallium-204	4 d	β	▪ Measure dust and pollutant levels ▪ Gauges the thickness of misc. materials
Thorium-229	7300 y	α γ	▪ Increases longevity of fluorescent lights
Throium-230	75,400 y	α γ	▪ Coloring and fluorescence in colored glazes and glassware
Tritium	12 y	β	▪ Biomedical research ▪ Life science and drug metabolism ▪ Self-luminous aircraft and commercial exit signs ▪ Luminous dials, gauges and wrist watches ▪ Luminous paint ▪ Geological prospecting and hydrology
Uranium-234	246,000 y	α γ	▪ Dental fixtures
Uranium-235	704,000,000 y	α γ	▪ Nuclear power plant fuel ▪ Fluorescent glassware, a variety of colored glazes and wall tiles
Xenon-133	5.2 d	β	▪ Nuclear medicine

Source: Nuclear Regulatory Commission

Instrumentation[1]

- Geiger-Mueller detector
- Scintillation detector
- Ion Chamber detector
- Dosimeter Model 3500
- SAIC PD-10i Pocket Dosimeter

Geiger-Muller Detector

- Can detect alpha, beta, gamma, and X-ray.
- Pros
  - Detects all types of radiation.
- Cons
  - Does not discriminate between radiation types
  - Low gamma detection efficiency.
- Typically a pancake probe.

Scintillation Detector (NaI)

- Typically a cylinder probe.
- Can detect alpha, beta, gamma, and X-ray.
- Pros
  - Highly efficient
  - Durable
- Cons
  - Specific to only gamma and X-rays.

Ion Chamber

- Can detect high-energy beta and gamma.
- It is typically a gas filled chamber and has is an accurate measurement of exposure rate.
- Pros
  - Accurate measurement of exposure rate.
- Cons
  - Not sensitive to low energy radiation.

Dosimeter Corporation, Model 3500

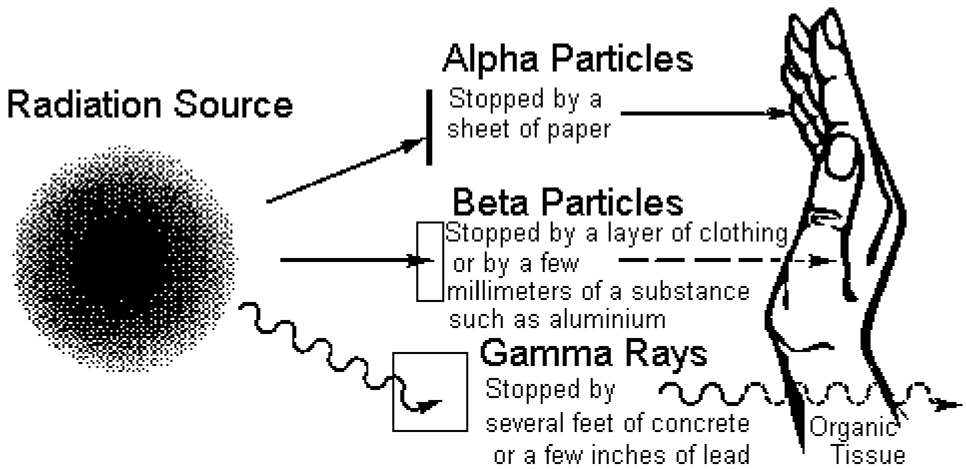
- Not sensitive to low energy radiation.
  - A direct reading instrument used for the measurement and detection of radioactive sources

SAIC PD-10i Pocket Dosimeter

- A pocket dosimeter used for measurement radiation, dose range 2uR to 999 R.

[1] Source: START course "Everything You Wanted to Know About Radiation, But Were Afraid to Glow" 2003

The Penetrating Powers of Alpha and Beta Particles and Gamma Rays



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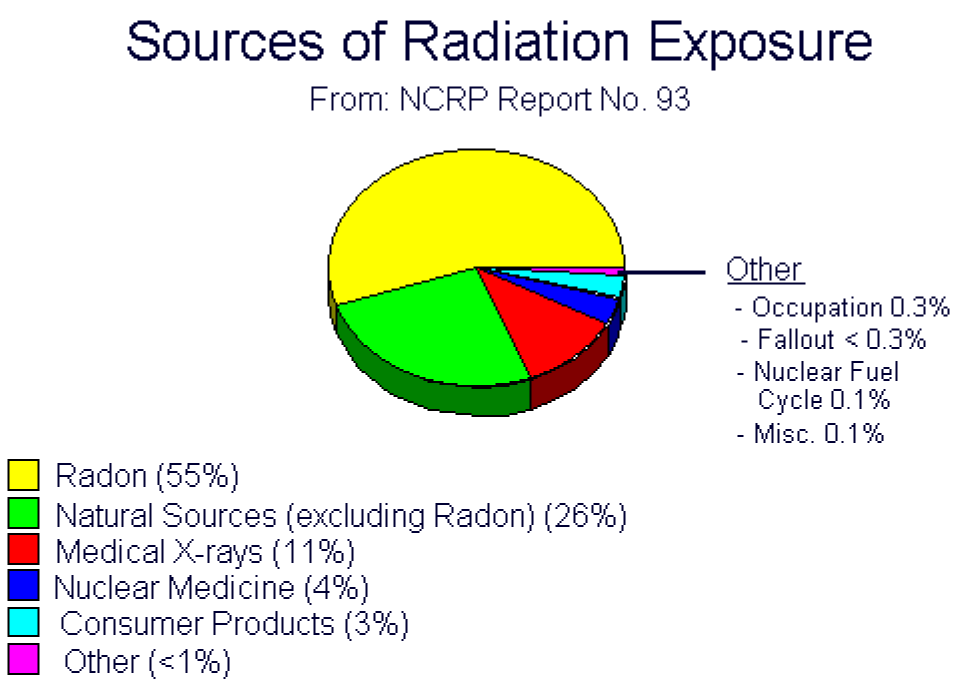

[2] U.S. EPA,Office of Radiation & Indoor Air Radiation Protection Division EPA 402-F-98-009 May 1998 Ionizing Radiation Series No. 1