Radiation Safety Office

Module 2
Fundamentals of Basic Radiation

Topics Covered in This Module

- Radiation Found in the Environment,
- Types of Radiation,
- Exposure, Absorbed Dose, and Dose Equivalent.

Radiation Found in the Environment

Natural Sources of Radiation

- Cosmic,
- Terrestrial,
- Internal,
- Inhaled.

Cosmic Radiation

- High energy particles and photons from the sun and other sources outside the earth’s atmosphere:
  - Our atmosphere provides shielding from cosmic radiation.
  - An increase in altitude results in an increase in exposure.
    - For example, at sea level, average exposure is 26 mrem/year but in Denver, Colorado, the average exposure is 50 mrem/year.

Terrestrial Radiation

- Radiation from radioactive materials occurring naturally in the earth's crust.
- In the United States, highest radiation levels found on the eastern slope of the Rockies in Colorado Plateau Area Range 75 to 140 mrem/year and average 90 mrem/year.
- In the United States, lowest radiation levels found on the Atlantic Coast in the Atlantic and Gulf Coastal Plain Range 15 to 35 mrem/year and average 23 mrem/year.

Inhaled Radiation

- Primarily from Radon (^{222}Rn) and its daughters.
- ^{222}Rn is released from the soil as Radium-226 (^{226}Ra) and then it decays to Radon.
  - Radium is part of the Uranium-238 (^{238}U) decay chain.
- Levels vary widely from area to area,
  - Average dose is 200 mrem/year.
- Dose may be enhanced by poor ventilation or the use of uranium containing building materials.

Internal Radiation

- Radiation from radioactive materials incorporated in the human body:
  - Carbon-14 (^{14}C),
  - Potassium-40 (^{40}K),
    - Total dose of 39 mrem/year (due mostly to ^{40}K).

Types of Radiation

What is Radiation?

- Radiation is the emission of energy as electromagnetic waves or as moving subatomic particles through space or through a material.
- Radiation is often categorized as either ionizing or non-ionizing depending on the energy of radiated particles or waves.
- Ionizing radiation carries more than 10 eV, which is enough to ionize atoms and molecules and break chemical bonds.

Particulate Radiation Vs. Electromagnetic Radiation

- Particulate Radiation:
  - Alpha Particle,
  - Beta Particle,
  - Neutron.
- Electromagnetic Radiation:
  - Photon,
  - Gamma.

Electromagnetic Radiation

- Oscillating electric and magnetic fields that transfer energy to matter via photon or wave interactions.
- Electromagnetic radiation includes radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays.

Charged Radiation Vs. Uncharged Radiation

- Charged Radiation:
  - Alpha Particle,
  - Beta Particle.
- Uncharged Radiation:
  - Photon,
  - Neutron.

Ionizing Radiation Vs. Non-Ionizing Radiation

- Ionizing Radiation:
  - Has enough energy to completely remove an electron from an atom.
  - Alpha, beta, gamma, neutron, and X-rays.
- Non-Ionizing Radiation:
  - Not enough energy to completely remove an electron from an atom.
  - Visible light, Ultra-Violet, infrared, microwaves, and radio waves.

Exposure, Absorbed Dose and Dose Equivalent

Exposure

- The sum of the charges of one sign produced by photons in a given mass of air.
- The SI unit of exposure is the Coulomb/kilogram (C/kg).
- The traditional unit is the roentgen (R).
- 1 R = 2.58×10^{-4} C/kg.
  - This unit is only defined for photons of less than 3 MeV energy in air.

Absorbed Dose

- The energy deposited in or absorbed by an object per unit mass.
- Applies to all radiation at all energies in all absorbers.
- The SI unit of absorbed dose is the Gray (Gy).
- The traditional unit is the rad.
- 100 rad = 1 Gy = 1 J/kg.
- Symbol is D.

Dose Equivalent

- The energy deposited in an object per unit mass (D) multiplied by a “quality factor” (Q, quality factor accounts for the different biological effectiveness of different types of radiation).
- The SI unit of dose equivalent is the Sievert (Sv).
- The traditional unit is the rem.
- 100 rem = 1 Sv.
- Symbol is H, $H = D \times Q$.

Recommended Quality Factors

Radiation Type	QF
X-Ray, Gammas, and betas	1
Neutrons	2-11
Neutrons with unknown energy	10
High Energy photon	10
Alpha particles, fission fragments, heavy nuclei	20

Conversion

- For the purpose of radiation protection, it is assumed that 1 R = 1 rad = 1 rem.
  - R is only defined for photons,
  - The quality factor is 1 for photons,
  - The actual “conversion” factor is dependent on the absorber,
  - 1 R is actually less than 1 rad (1 R = 0.97 rad for tissue).