Radiation Fundamentals

Radiation Safety Training

Module 1

- Radioactivity
  - Radioactivity is the process of unstable (or radioactive) atoms becoming stable.
  - This is done by emitting radiation.
  - This process over a period of time is referred to as radioactive decay.
- Radioactive material
  - Radioactive material is any material containing unstable atoms that emit radiation.

Definitions

Questions? E-mail the RSO: sarah.grant@wku.edu

- Radioactive Half-Life
  - The time it takes for one half of the radioactive atoms present to decay.
- Radioactive contamination
  - Radioactive contamination occurs when radioactive material is uncontained and in an unwanted place. (There are certain places where radioactive material is intended to be).
  - Our goal is to prevent radioactive contamination.

Definitions

Ionizing radiation

- Ionizing radiation is energy (particles or rays) emitted from radioactive atoms, and some devices, that can cause ionization.

- Examples of devices that emit ionizing radiation are X-ray machines, accelerators, and fluoroscopes.

    - Exposure to ionizing radiation, without exposure to radioactive material, will not result in contamination of the worker.

Definitions

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Non-ionizing radiation

- Electromagnetic radiation that doesn't have enough energy to ionize an atom is called "non-ionizing radiation."
- Examples of non-ionizing radiation are radar waves, microwaves, and visible light.

Definitions

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- The four basic types of ionizing radiation of concern at Western Kentucky University are
  - alpha particles
  - beta particles
  - gamma or X rays
  - neutrons

Four Basic Types of Ionizing Radiation

- Deposits a large amount of energy in a short distance of travel.
  - Can only penetrate very short
  - Range in air is about 1-2 inches.
- Shielding
  - Most alpha particles are stopped by a few centimeters of air, a sheet of paper, or the dead layer (outer layer) of skin.
- Biological hazards
  - Alpha particles are not considered an external radiation hazard because they are easily stopped by the dead layer of skin.

Alpha Particles

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- Range
  - Beta particles have a limited penetrating ability.
  - The range in air of beta particles depends on the energy of the beta particle and can be as short and an inch (^{3}H) to as far a 20 feet. (^{32}P or ^{90}Sr).
- Shielding
  - Beta particles are typically shielded by plastic, glass, or safety glasses.
- Biological hazards
  - Can be an internal hazard if ingested or inhaled,
  - Potentially hazardous to the skin and eyes.
  - P-32 is commonly used at WKU; this high energy beta emitter (1.7 MeV) can result in radiation exposure to the whole body.

Beta Particles

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- Gamma rays are very similar to X rays.

- Range
  - Very high penetrating ability.
  - The range in air is very far. It will easily go several hundred feet.
- Shielding
  - Best shielded by very dense materials, such as lead.
  - Water or concrete, although not as effective as the same thickness as lead, are also commonly used, especially if the thickness of shielding is not limiting.
- Biological hazards
  - Gamma/X-ray radiation can result in radiation exposure to the whole body.

Gamma rays/X-rays

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- Range
  - Neutrons have a relatively high penetrating ability and are difficult to stop.
  - The range in air is very far. Like gamma rays, they can easily travel several hundred feet in air.
- Shielding
  - Neutron radiation is best shielded by materials with a high hydrogen content such as water, concrete, or plastic.
- Biological hazards
  - Neutrons are a whole body hazard due to their high penetrating ability.
- Sources
  - Contact the RSO if you have questions about the specific neutron emitting isotopes or machines your lab possesses.

Neutrons

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- Rad (Radiation absorbed dose)
  - A unit for measuring absorbed dose in any material.
  - Is defined for any material.
  - Applies to all types of radiation.

- Does not take into account the potential effect that different types of radiation have on the body.

- Rem (Roentgen equivalent man)
  - Is the most commonly used unit for measuring dose equivalence
  - Takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation.

  - 1 rad = 1000 millirad (mrad) = 1 rem = 1000 mrem

Units of Measure for Radiation

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- The Quality Factor (QF) is used as a multiplier to reflect the relative amount of biological damage caused by the same amount of energy deposited in cells by the different types of ionizing radiation. Rem = rad x QF.

  - Quality Factors:
  - alpha = 20
  - beta = 1
  - gamma/x-ray = 1
  - neutron = 2-11 (depending on the energy)

Units of Measure for Radiation

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- Radiation dose rate is the dose per time.
- Example:

  Radiation dose rate = dose/time.

  Radiation dose equivalent rate = mrem/hr.

  Radiation absorbed dose rate = mrad/hr.

Radiation Dose and Dose Rate

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- *Radiological Worker Training*, DOE Handbook, DOE-HDBK-1130-98, October 1998, Reaffirmation with Errata May 2004, Change Notice No. 1, February 2005.

Reference

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