Al-Mustaqbal University
College of Science
Department of Medical Physics
The Fourth Stage
First Course

Radiation Protection

LECTURE SIX

Radiation protection rules (Solutions to the Problems)

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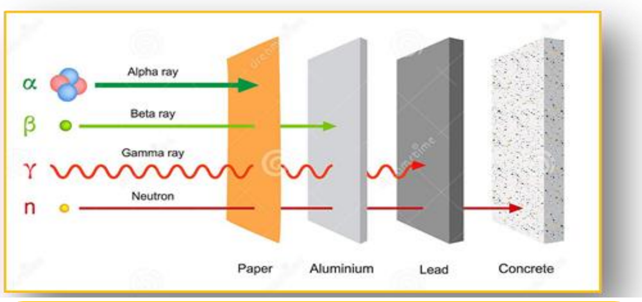

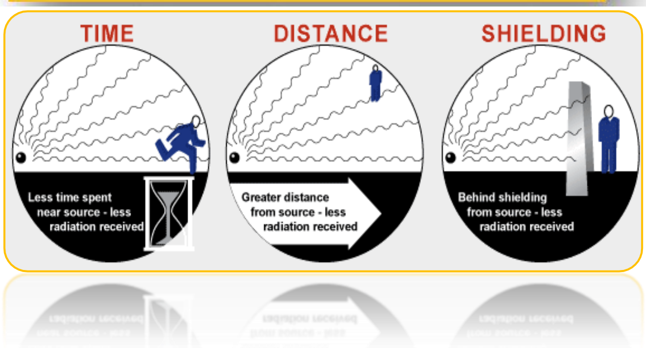

LECTURE SIX: Radiation protection rules

- **Introduction**
- **Radiation Protection**
- **Method (rules) of Radiation Protection**
  - **Time (Limiting Time)**
  - **Distance**
  - **Shielding**
- **Shielding properties of Alpha particles**
- **Shielding properties of Beta particles**
- **Principles of Radiation Protection**

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❖ Introduction

Fundamental to radiation protection is the avoidance or reduction of dose using the simple protective measures of time, distance and shielding. The duration of exposure should be limited to that necessary, the distance from the source of radiation should be maximized, and the source shielded wherever possible.

❖ Radiation Protection

It is the science and practice of protecting people and the environment from the harmful effects of ionizing radiation.

❖ Method of Radiation Protection

The three basic methods used to reduce the risk of external radiation are:

One: Time (limiting time)

Two: Distance

Three: Shielding

Good radiation protection practices require optimization of these fundamental techniques.

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- **ONE : Time (Limiting Time)**

This represent the **amount of radiation that accumulates (pile up) in an individual (body),** which depend on how long the body stays in the radiation field.

- **Dose (mrem) = Dose Rate (mrem/hr) x Time (hr)** --------------- **(1)**

Therefore, to limit a person's dose, one can restrict the time spent in the area. How long a person can stay in an area without exceeding a prescribed (specified) limit of radiation is called the **"stay time"** and is calculated from the relationship:

- **Stay Time = limit(mrem) / Rate Dose(mrem/hr)** --------------- **(2)**

Example: How long can a radiation worker stay in a 1.5 rem/hr radiation field if we wish to limit his dose to 100 mrem?

Answer : Stay Time = (100 mrem / 1500 mrem/hr) = 0.067 hr = 4 minutes

- **TWO : Distance**

The amount of radiation an individual receives will also depend on how **close the person is to the source**. The relationship between radiation hazards and the distance from the source can be organized by the following relationship, which is called **"The Inverse Square Law"**

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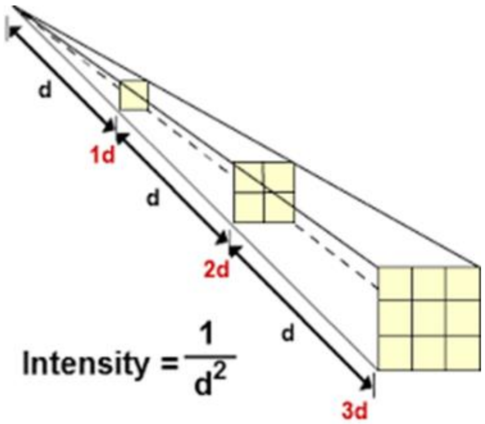
Point sources of X-ray and gamma radiation follow the inverse square law, which states that the intensity of the radiation (I) decreases in proportion to the inverse of the distance from the source (d) squared:



$I \alpha 1/d^2$

(Intensity) **α** 1/ (distance)^2

Inverse Square Law

$$\frac{I_1}{I_2} = \frac{d_2^2}{d_1^2}$$

- **$I \alpha 1/d^2$**

This can be rewritten:

$I = K (1/d^2)$ where K is a constant of unknown value.

So, for an intensity I_1 at distance $d_{1,}$ and another intensity I_2 at distance d_2:

$I_1 = K (1/d_1^2)$

$I_2 = K (1/d_2^2)$

Now solve for the relationship by eliminating K:

$I_1 / I_2 = (K /d_1^2/k/d_2^2)$

$I_1 / I_2 = d_2^2 / d_1^2$

Or $I_1 d_1^2 = I_2 d_2^2$

Therefore, by knowing the intensity at one distance, one can find the intensity at other distance.

<u>Example:</u> The exposure rate **one foot** from a source is **500 mR/hr**. What would be the exposure rate **three feet** from the source?

Answer :

$I_1 = 500$ mR/hr

$d_1 = 1$ foot

$d_2 = 3$ feet

$I_2 = I_1 d_1^2 / d_2^2$

$I_2 = (500*(1)^2 / (3)^2)$

$I_2 = (500 / 9) = 55.6$ mR/hr

Gamma Constants

Gamma radiation levels (in R/hr) for one curie of many radionuclides at a distance of one meter have been measured. These gamma constants can be used to determine 1. The expected exposure rates at a given distance (using the inverse square law) for a known quantity of a radionuclide, or 2) the activity of a radionuclide from a measured exposure rate. . To determine the gamma radiation level in R/hr at one meter per curie, or equivalently, mR/hr at one meter per millicurie, you must divide the tabulated gamma constants (Γ) by 10.

Gamma Exposure Rate Formula

The exposure rate from a gamma point source can be approximated from the following expression:

$$\text{mR/hr} = \frac{6CEf}{d^2}$$

Where C is the activity of the gamma emitter, in mill-curies

E is the gamma ray energy in MeV

f is the fraction of disintegration yielding the gamma of energy E

d is the distance from the source in feet

If more than one gamma ray is emitted by the radionuclide of interest, then the contribution from each one must be calculated separately and summed. This expression is accurate to about 20% for gamma emitters with energies ranging from 0.07 MeV to 4 MeV.

- **THREE : Shielding**

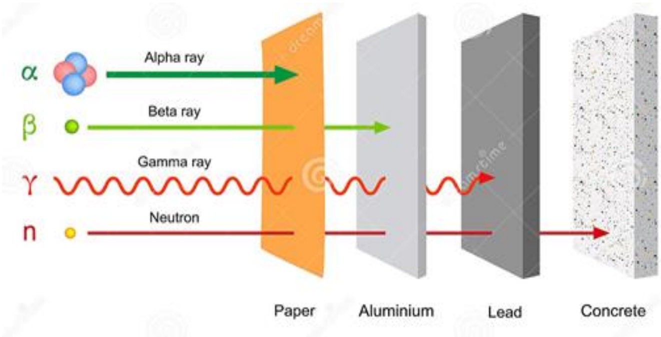
When reducing the time or increasing the distance may not be possible, one can choose shielding material to reduce the external radiation hazard. The material suitable for use as shields depends on the following

(i) Type of radiation.

(ii) Its energy.

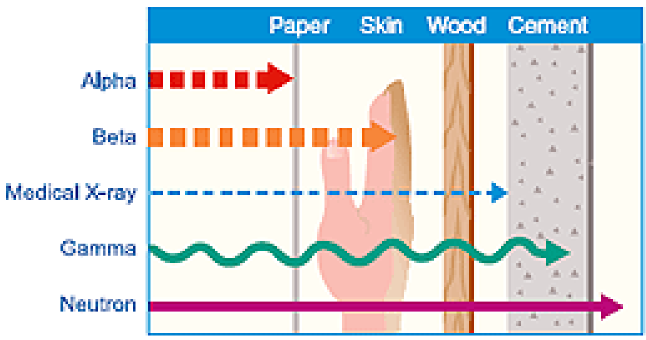
❖ Shielding properties of Alpha particles

- Alpha particles are **easily shielded**.
- A thin piece of **paper** or **several cm of air** is usually enough to stop them.
- Alpha particles present **no external radiation hazard**.



❖ Shielding properties of Beta particles

- Beta particles are **more penetrating** than alpha particles.
- Beta shields are usually made of **aluminum**
- The range of beta radiation for various energies in air, plastic and various materials.



❖ Shielding properties of Gamma radiation & X-ray

- Gamma rays are not easy to stop
- Gamma rays cannot be stopped by paper, wood, or the human body
- Gamma rays stop using a lead wall.

❖ Principles of Radiation Protection

- **Justification:** Any decision that changes exposure to radiation must be made carefully.
- **Optimization of Protection:** The dose of radiation must be kept as low account with any process.
- **Dose Limitation:** The total dose to any person should not exceed the appropriate limit.

Bubble sheet questions

Q1- The relationship between radiation hazards and the distance from the source can be organized by Inverse Square Law, if intensity I_1 at distance d_1, and intensity I_2 at distance d_2; So the following can be written

A- I_1d_1/I_2d_2 B- $I_1 / I_2 = (K /d_1^2/k/d_2^2)$ C- $I_1 / I_2 = d_2 / d_1$ D- I α 1/d E- all of them

Q2- The exposure rate <u>three foot</u> from a source is <u>100 mR/hr</u>. What would be the exposure rate <u>two feet</u> from the source?

A- 22.3 mR/hr B- 52.25 mR/hr C- 11.13 mR/hr D- 75 mR/hr E- none all of them

Q3- When reducing the time or increasing the distance may not be possible, one can choose -------------- to reduce the external radiation hazard.

A- Time B- limiting time C- distance D- shielding E- all of them

Q4- Materials suitable for use as shields to protect against radiation hazard depend on ---------------------------.

A- limiting time B- stay time C- dose rate D- type and energy of radiation E- all of them

Q5- The shielding properties of ------------------- are a thin piece of paper or several cm of air.

A- alpha particles B- beta particles C- gamma radiation D- X-ray E- gamma ray