Radiation protection –Theoretical Lec4. Radiation Quantities And Units

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Radiation Quantities and Units

- Activity
- Exposure
- Absorbed Dose
- Equivalent dose
- Effective Dose

Quantity	S.I Units	Traditional Units
Exposure	Coulomb/Kg	Roentgen (R)
Absorbed dose	Gray (Gy)	Rad
Equivalent dose	Sievert (SV)	Rem
Effective dose	Sievert (SV)	Rem

Activity

- The rate of decay, or the number of nuclei of a radionuclide decaying per second is known as its **activity.**

$$A = \frac{dN}{dt}$$

- Units of Activity:

- The SI unit of activity is **Becquerel (Bq)**
- The old classical unit is **Curie (Ci).**

Exposure

- The quantity exposure describes an x-ray or gamma ray field. It is a measure of the amount of ionization produced in air by the x-rays or gamma rays in air.

$$X = \frac{dQ}{dm}$$

- The SI unit of exposure is 1 C/kg
- The old classical unit is Roentgen (R)

Absorbed Dose

- Absorbed Dose:(Any medium, any type of radiation)

- **The ionizing radiation energy absorbed per unit mass of the matter is known as absorbed dose.**
- $$D = \frac{dE}{dm}$$
- Units of absorbed dose
- The SI unit of absorbed dose is J/kg and the special name is Gray (Gy)
- 1 Gy = 1J/kg
- The old classical unit is Rad
- 1 Rad = 100 ergs/g

Relation between Gy and Rad

$1\ Gy = 1\ J/Kg \qquad 1J = 10^7\ ergs$

$= 10^7\ ergs/1000g$

$= 10^4\ ergs/g$

$= 100\ (100\ ergs/g)$

$= 100\ Rad$

$1\ Gy = 100\ Rad$

Equivalent Dose

- **Equivalent Dose is a quantity which takes into effect 'radiation quality', which relates to the degree to which ionizing Radiation will produce biological damage.**

- **resulting quantity can then be expressed numerically in**

  Equivalent Dose = Radiation Weighting Factor (W_R) × Dose (D)

- **SI: Sieverts (Sv)**
- **The old units: Rem**

- **The quantity is independent of the absorbing material a(i.e. tissue).**

Equivalent Dose

$$H_T = w_R \times D_{T,R}$$

H_T : Equivelent dose in Sievert (Sv)

$D_{T,R}$: Absorbed dose in Gray (Gy)

w_R : Radiation weighting factor

If we have a field composed of different types of radiation; (i.e. different w_R) the equivalent dose is:

$$H_T = \sum_R w_R \times D_{T,R}$$

Equivalent Dose

Radiation Weighting Factor (W_R) for some radiations

Photons, all energies	1
Electrons, all energies	1
Neutrons, energy (E):	
E < 10 keV **(Slow)**	5
10 keV < E < 100 keV	10
100 keV < E < 2 MeV **(Fast)**	20
2 MeV < E < 20 MeV	10
E > 20 MeV	5
Protons, other than recoil protons, E > 2 MeV	5
Alpha particles, fission fragments, heavy nuclei	20

Equivalent Dose

Example1: A person has absorbed a fast neutron dose of 0.2 mGy; calculate the equivalent dose?

Solution:

$$H = D \times w_R$$

$$= 0.2 \times 20 = 4\ mSv$$

Equivalent Dose

Example 2: A person has received dose from the followings: (0.4mGy slow neutrons, 6.0mGy gamma rays and 0.1mGy alpha particles); calculate the equivalent dose?

Equivalent Dose	D	×	w_R	=	H
Slow Neutrons	0.4 mGy	×	5	=	2 mSv
Gamma Rays	6.0 mGy	×	1	=	6 mSv
Alpha Particles	0.1 mGy	×	20	=	2 mSv
Total				=	**10 mSv**

The Effective Dose

- **The Effective Dose is obtained by taking a Tissue Weighting Factor (W_T) and multiplying by the Equivalent Dose (H_T) which relates to the organs / tissues under consideration. Units Sv or Rem**

$$E = w_T \times H_T$$

E : Effective dose in Sievert (Sv)

H_T : Equivalent dose in Sievert (Sv)

w_T : Tissue weighting factor

If we have a field irradiate different types of tissues; (i.e. different w_T) the effective dose is:

$$E = \sum_T w_T \times H_T$$

Effective Dose

Tissue or organ	w_T
Gonads	0.20
Bone marrow (red)	0.12
Colon	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Esophagus	0.05
Thyroid	0.05
Skin	0.01
Bone Surface	0.01
Remainder	0.05

Example: During the year, a worker recived 5 mGy from internally deposited alpha particles, in the lung, 140 mGy from beta particles in the thyroid and 1.2 mGy externally from uniform whole-body proton irradiation. Calculate the effective dose for this worker?

Solution:

$$H_{Lung} = 5\times20 = 100\ mSv$$

$$H_{Thyroid} = 140\times1 = 140\ mSv$$

$$H_{Whole\text{-}Body} = 1.2\times5 = 6\ mSv$$

$$\Sigma E = (100\times0.12)_L + (140\times0.05)_T + (6\times1)_W = 25\ mSv$$