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Calculation and Study the Bremsstrahlung Dose rate of (^{90}Sr) Beta Source

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Abstract: ***The bremsstrahlung dose rate for beta particles through four materials (polyethylene, wood, aluminum and iron) were investigated as a function of the shielding material type , shield thickness and the shield to source distance. The bremsstrahlung dose rate were obtained using computer program called Rad Pro Calculator (version 3.26) with (^{90}Sr) beta source having anmaximum energy (0.546) MeV. Results show that the number of bremsstrahlung produced in the beta shield material increases as the atomic number of the material increases bremsstrahlung dose rate values decrease with increase of the thickness and shield to source distance***

Keywords: Bremsstrahlung, beta source.

1. Introduction

The shielding of radiation is an important issue, especially with regards to human safety. How much and what type of material should be used to adequately stop various forms of radiation must be known(1).Among various radiation sources, beta sources are widely used in industrial and medical applications. As beta particles travel, they interact with the atoms in their travel path and lose their energy. The electron or positron energy lost reappears as x-rays called bremsstrahlung. So, one of the problems of the use of radiation shields beta regard to secondary emission of electromagnetic radiation, which produces rapid slowdown beta for a few minutes, which is known as Bremsstrahlung and it requires shielding against beta particles reserves.(2)

2. Bremsstrahlung Radiation Yield

Radiation yield is defined as the average fraction of its energy that a beta particle radiates as bremsstrahlung in slowing down completely. An estimate of radiation yield can give an indication of the potential bremsstrahlung hazard of a beta-particle source. If electrons of initial kinetic energy T in MeV are stopped in an absorber of atomic number Z, then the radiation yield is given approximately by the formula(3):

$$Y = \frac{6\times10^{-4}\times Z\times E}{1+(6\times10^{-4}\times Z\times E)} \tag{1}$$

Y = Bremsstrahlung Yield

E = Maximum energy of beta in MeV.

Z = Atomic number of shielding material.

if the shielding material is a compound or a mixture, instead of a pure element, an effective atomic number (Z_{eff}) should be used in Eq(1) ,The value of (Z_{eff}) is given by the following equation(4):

$$Z_{eff} = \frac{\sum_i^l \frac{W_i\times Z_i^2}{A_i}}{\sum_i^l \frac{W_i\times Z_i}{A_i}} \tag{2}$$

A_i ,W_i and Z_i are mass number, weight fraction and atomic number of the ith element, respectively.Z_{eff} for tow materials (polyethelen and wood) are evaluated using eq.(2)

3. Bremsstrahlung Dose Rate

Bremsstrahlung dose rates were calculated for the different materials using a computer program called Rad Pro Calculator (version 3.26). This software allows us to first calculate the Bremsstrahlung dose-rate coming from the beta shield and allows us select a second shield and then calculate the secondary shielded dose-rate.

In the present work, we will study the dose rate of beta Bremsstrahlung radiation for four materials (polyethylene , wood , aluminum , iron) using different shield to source distant (1-10) cm and different values of the shield thickness (1-10) mm. Measurement have been carried out using beta source (^{90}Sr)with maximum energy (0.546 MeV) .

4. Result and Discussion

Table (1) shows the values of bremsstrahlung yield and dose rate corresponding to different atomic numbers. Fig (1) and (2) .the bremsstrahlung yield and dose rate was displayed as a function of the atomic number of shielding material type. We can be seen from this figures that the bremsstrahlung yield and dose rate increased with the increase of the shield atomic number .This mean, for human radiation protection, a low Z shield material is a better choice because a higher Z shield could actually expose them to more radiation energy from the Bremsstrahlung than the original beta exposure would have been, especially at a distance.

The values of dose rate for different distance show in table (2). Fig (3) show the change of dose rate with the source to shield distance. This figure show that the dose rate values decrease with the increased of distance , this behavior can be explain as the mean path length , which are covering the beta particles emitted by the source, will be longer than the real shield thickness at small values of distance[5].

Table (3) shows the values of dose rate for different thickness. Fig (4) shows the change of dose rate with the thickness of shield. From this figure one can see that the dose rate decrease with the increased of thickness. This behavior can be explained by the increase of the shield thickness, the probability of interaction beta particles with atoms will increase and therefore the dose rate will decrease.

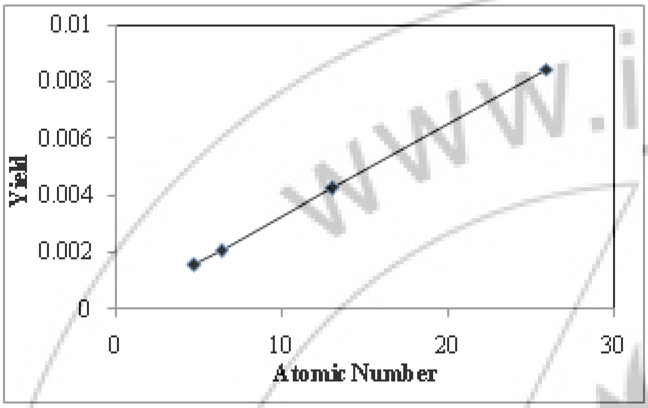

Figure 1:.Bremsstrahlung yield as a function of Atomic number

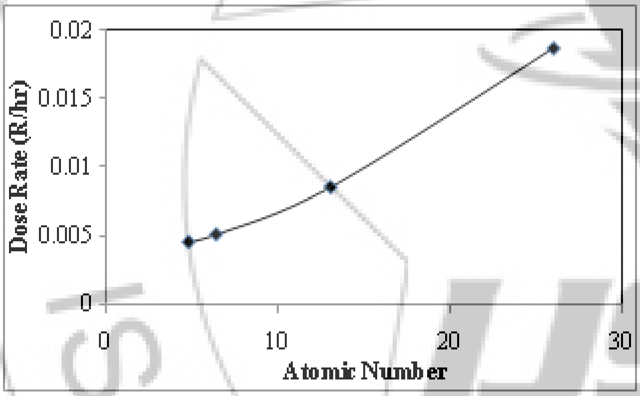

Figure 2: Dose rate as a function of Atomic number

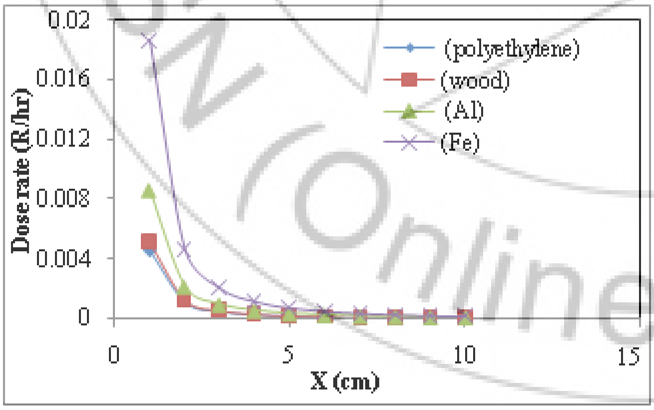

Figure 3: Dose rate as a function of shield to source distance (X).

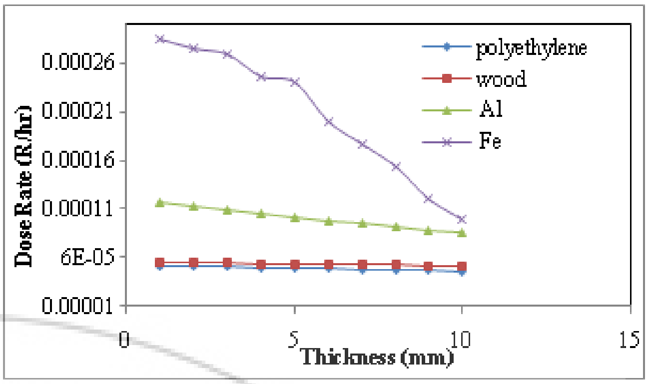

Figure 4: Dose rate as a function of shield thickness

Table 1: Values of atomic number Z, Yield Y and Dose rate for different shielding materials.

shield material	Z	yield (Y)	dose rate (R/hr)
polyethylene	4.74	0.00155	0.004603
wood	6.344	0.002074	0.005155
Al	13	0.004241	0.008575
Fe	26	0.008446	0.01868

Table 2: Variation of Bremsstrahlung Dose rate with distance for different shielding materials

Distance (cm)	Dose rate (R/hr) (polyethylene)	Dose rate (R/hr) (wood)	Dose rate (R/hr) (Al)	Dose rate (R/hr) (Fe)
1	0.004603	0.005155	0.008575	0.01868
2	0.00115	0.001288	0.002143	0.00467
3	0.0005114	0.0005728	0.0009528	0.002075
4	0.0002876	0.0003221	0.0005359	0.001167
5	0.0001841	0.0002061	0.0003429	0.0007472
6	0.0001278	0.0001431	0.0002381	0.0005189
7	0.00009392	0.000105	0.0001749	0.0003812
8	0.0000719	0.00008053	0.0001339	0.0002918
9	0.00005681	0.00006363	0.0001058	0.0002306
10	0.00004601	0.00005154	0.00008573	0.0001867

Table 3: Variation of Bremsstrahlung Dose rate with Shield thickness for different shielding materials

thickness (mm)	Dose rate (R/hr) (polyethylene)	Dose rate (R/hr) (wood)	Dose rate (R/hr) (Al)	Dose rate (R/hr) (Fe)
1	0.00005178	0.00005486	0.0001157	0.0002841
2	0.00005112	0.00005448	0.000112	0.0002744
3	0.00005045	0.0000541	0.0001082	0.0002685
4	0.00004979	0.00005373	0.0001047	0.0002456
5	0.00004914	0.00005336	0.0001013	0.0002395
6	0.0000485	0.00005299	0.00009797	0.0001985
7	0.00004786	0.00005262	0.00009475	0.0001756
8	0.00004724	0.00005226	0.00009164	0.0001525
9	0.00004662	0.00005189	0.00008864	0.0001211
10	0.00004601	0.00005154	0.00008573	0.0001

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