DEPLETED URANIUM AS A RADIATION PROTECTION MATERIAL IN RADIOTHERAPY

Goran Kolarević[1,2], Dražan Jaroš[1,2], Dragoljub Mirjanić[2],
[1]Center for Radiation Therapy, International Medical Centers-Affidea, Banja Luka, Bosnia and Herzegovina
[2]Faculty of Medicine, University of Banja Luka, Bosnia and Herzegovina

1. Background/Aim.

Natural uranium contains three isotopes, uranium-234 (0.005 %), uranium-235 (0.7 %) and uranium-238 (99.3 % percent by mass). Through the enrichment process (fission fuel), the share of uranium-235 increases from 0.7% to (3-5) %. A by-product of the enrichment process is depleted uranium (DU) with uranium-234 (0.002 %) and uranium-235 (0.2 %). DU is a weaker irradiator (by around 40 %) than the natural uranium. Due to its high density (19.1 g/cm^3, 1.7 times denser than lead), although radioactive itself, DU is suitable as a protective material against ionizing radiation for radiotherapy (RT) bunkers. Half-value layer (HVL) is a thickness that reduces the dose to 50 % and tenth-value layer (TVL) ten times..

This type of units require construction protection against ionizing radiation (figure 1) [1]. The HVL and TVL values for gamma beam ^{60}Co, for materials most commonly used for shielding in radiotherapy are given in table 1.

Table 1. The HVL and TVL values of shielding materials most commonly used in RT [2]

	HVL (cm) for ^{60}Co	TVL (cm) for ^{60}Co
Concrete	6.2	21
Steel	2.16	7
Lead	1.25	4
DU	0.69	0.23

The aim of the study is to calculate the values of the primary barrier thicknesses (towards the control panel and exterior wall) for concrete, steel, lead and DU in the case of ^{60}Co devices, based on IAEA recommendations[1].

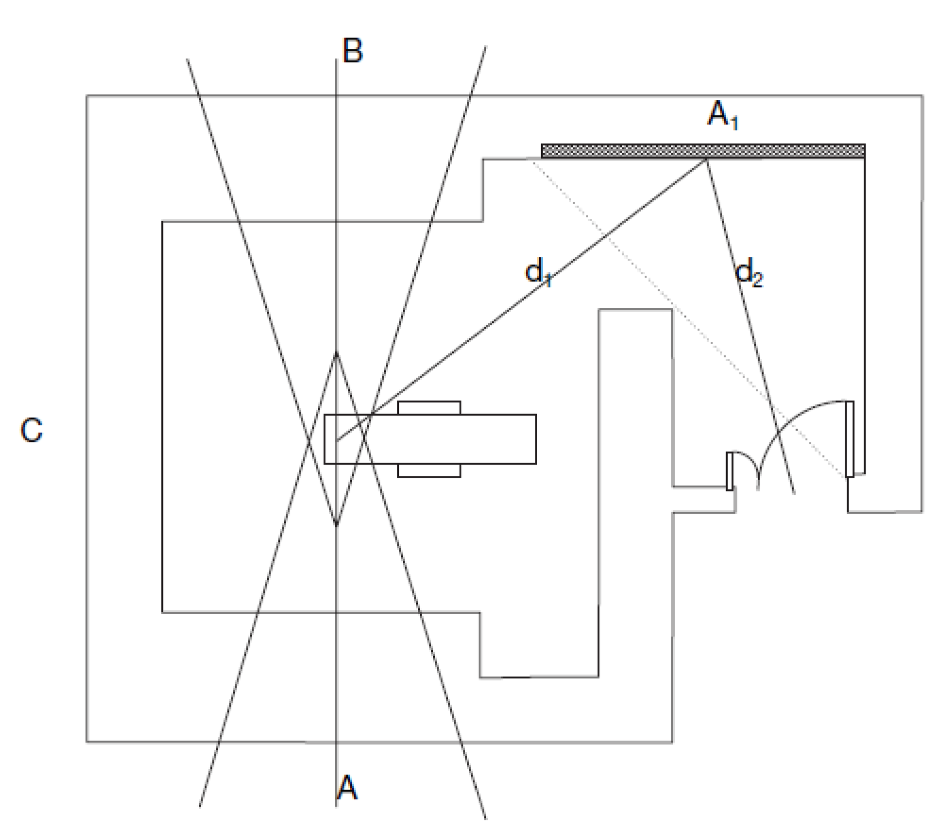

Figure 1. Example layout of ^{60}Co devices treatment room

2. Methods.

The ^{60}Co unit operates at energies 1.17 and 1.33 MeV. The calculation was based on the average workload, 40 patients/day for 5 days/week, with an average dose of 3 Gy/patient at 80 cm. Attenuation of the barrier *B* is given by Eq.(1)[1]:

$$B = \frac{P(d + \mathrm{SSD})^2}{WUT} \quad (1)$$

where *P* is the allowed dose per week (0.12 mSv/week) outside the barrier, *d* is the distance from the treatment position to the treatment console (3 m), SSD is the source–skin distance (0.8 m), *W* is the workload for 5 days per week (384 Gy/week) at 1 m, *U* is a fraction of the time during which the radiation under consideration is directed at a particular barrier (0.25) and *T* is the occupancy factor, it relates to the amount of time the adjacent rooms are occupied (treatment console=1).

The number (n) of TVLs required to achive the desired attenuation was determined by Eq.(2)[1]:

$$\mathrm{n\ TVLs} = \log_{10}\left(\frac{1}{B}\right) \quad (2)$$

3. Results.

Attenuation of the barrier was B=1.81·10^{-5} and nTVL=4.7435.

The thickness of the barrier to the treatment console was: 100, 34, 20 and 11 cm for concrete, steel, lead and DU resectively.

4. Conclusion

DU reduces the thickness of the protective walls (bunkers), in which the radiotherapy ^{60}Co device is placed, to a size 9 times smaller than concrete. Since it is radioactive itself, DU requires additional protection against ionizing radiation (alpha, beta and gamma) generated in the barrier as a result of radioactive decay. Increasingly, radiotherapy centers around the world are opting for DU as an optimal solution for protection, especially due to space savings.

References

1. International Atomic Energy Agency (IAEA). Radiation Protection in the Design of Radiotherapy Facilities, Safety Reports Series No47. Viena: IAEA. 2006.

2. National Council on Radiation Protection and Measurements (NCRP). Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities. Report No151. Bethesda: 2005.

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goran.kolarevic@affidea.com drazan.jaros@affidea.com mirjanicd@gmail.com