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A Study of Buildup Factor under Different Geometrical Conditions for 1332 keV Gamma Rays

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The simultaneous effect of longitudinal thickness and beam divergence has been studied on the buildup factor of six wood samples of popular, dek, toot, safeda, black talhi and beri for 1332 keV gamma rays. It has been observed that the buildup factor is maximum for beri and minimum for dek for a fixed longitudinal thickness and collimator size. The buildup factor is nearly unity for small collimator size and absorber thickness, but it increases with increase in longitudinal thickness and collimator size.

Key Words: Buildup factor, Wood.

INTRODUCTION

The transmitted photon spectra of different energy gamma rays through a medium give the detailed knowledge of the behavior of different gamma ray interaction processes in different energy regions. When a beam of mono-energetic gamma rays is incident on a shielding material in the form of a slab, the photons penetrate into medium, some of these interact with medium and others pass without any interaction. In the low and high energy regions the photoelectric effect and pair production processes results in the complete removal of photons from the incident beam by their absorption behavior, whereas in the medium energy region Compton scattering results only in degradation of energy of photon and not the completely removal of photons. The radiation flux after transmission consists of two parts, the uncollided part of the beam and the scattered fraction of the incident gamma rays. The uncollided part is represented by the following equation:

$$I = I_0 e^{-\mu x} \quad (1)$$

where I is intensity of radiation after passing through medium of thickness x, I_0 is intensity of incident radiations and μ is the linear attenuation coefficient. This equation is valid only for the well-collimated monoenergetic beam of gamma rays passing through a thin absorber.

But with the increase in thickness of the absorber between source and detector or by increasing the exposed area of the detector to the radiations, the probability for the low energy scattered photons reaching

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the detector is increased. Therefore, the measured intensity of the primary radiations after passing through the absorber is no longer the same as given by eq. 1 but is slightly greater. This distorts the validity of the exponential law of this equation. To study the contribution of secondary radiations due to the multiple scattering, it is necessary to introduce a correction factor, called buildup factor (B) as:

$$I = B\, I_o\, e^{-\mu x} \quad (2)$$

Using values of I_o, μ and the buildup factor, I can be determined for different absorber thicknesses under various collimation conditions. The value of buildup factor depends on the geometry, nature of the absorber and energy of incident radiations.

White[1] initially introduced the concept of gamma ray buildup factor and Fano[2] has confirmed its importance in attenuation measurements. Further the various workers such as Harima and Hirayama[3], Brar and Mudahar[4] and Singh *et al.*[5] have determined buildup factor for different materials like HCO materials, soil, Perspex, bakelite etc.

As the use of radiations is increasing in different fields, there seems a need to study the interaction of radiations with new type of materials from their applications point of view. In the present work, wood material has been selected to study the buildup factor to explore the applications of wood and its derived materials. Experimentally, the buildup factor values have been obtained for six types of wood materials under different conditions of dimensions and geometry for 1332 keV gamma rays.

EXPERIMENTAL DETAILS

In the present measurements, the gamma ray transmission geometry with NaI (Tl) detector (4.5 cm diameter and 5.1 cm thickness) has been used. The details of the geometry have been discussed previously[5]. A computerized 2K MCA plug-in card was used to record the pulse height spectra of gamma rays. The incident photons of 1332 keV were obtained from the decay of ^{60}Co radioactive isotope supplied by Bhabha Atomic Research Center, Mumbai, India. The positions of source and detector were fixed and the sample of wood was placed between source and the detector in a straight line. The incident and transmitted photon spectra were recorded for all the selected wood samples with the increase in thickness upto 58 cm to study the effect of longitudinal thickness on transmitted photon spectra. This procedure was repeated for different collimators placed at the face of the detector. The diameter of collimators was increased from 9 to 50 mm in five steps (9, 16, 20, 28 and 50 mm) so as to study the effect of beam divergence. Background spectra were recorded for the same time and subtracted

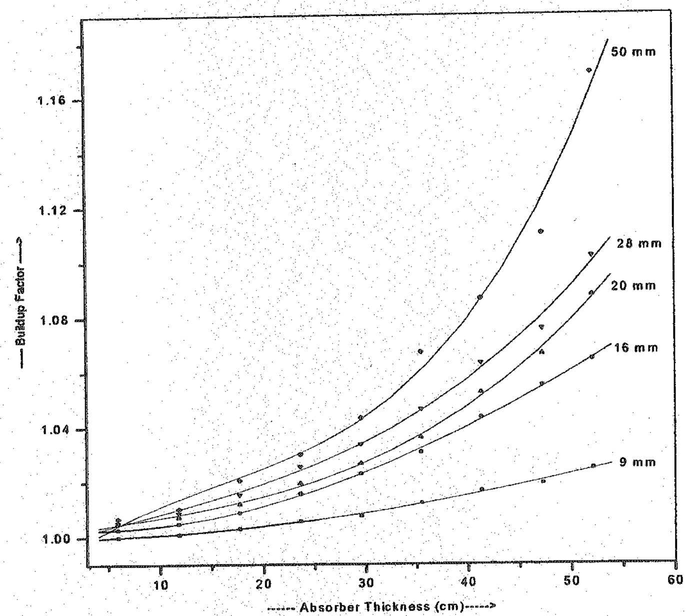

Fig. 1. Variation of build up factor of 1332 keV gamma rays with absorber thickness for a wood of beri for different collimator sizes

from each transmitted spectrum. Each spectrum was recorded for the time period of 1200 s to reduce the statistical error to less than 1%. To avoid the contribution of scattered photons from the walls, the whole instrumentation was placed at a suitable distance from the walls of the room.

RESULTS AND DISCUSSION

With the above-discussed experimental conditions and the procedure, the buildup factor values have been obtained for six samples of wood (popular, dek, toot, safeda, black talhi and beri). The variation of buildup factor with absorber thickness for different collimator sizes is shown in Fig. 1 for a particular wood of beri. Here it is observed that for a smaller thickness, the buildup factor is nearly unity for all the collimator sizes. But with increase of longitudinal thickness, the buildup factor values increases. This is because of the region that with the increase in longitudinal thickness, the number of multiple scattered photons increases which amounts to the increase of buildup factor value. It is also seen that for the fixed wood thickness, the buildup factor increases with increase in collimator size, which is due to the increase of exposed area of the detector to the incident and scattered part of the radiations. This increases the transmitted photon intensity, which results in the increase in the buildup factor value. The similar results have also been obtained for the remaining wooden samples.

The variation of buildup factor with absorber thickness for six different wood samples is shown in Fig. 2 for a fixed collimator size of 28 mm. From this graph it is observed that the buildup factor is different for different woods for the fixed thickness. It is maximum for beri and minimum for dek. It may be due to the Z dependence of the various interaction processes, which is different for different wooden samples. The similar results have also been obtained for the rest of collimator sizes.

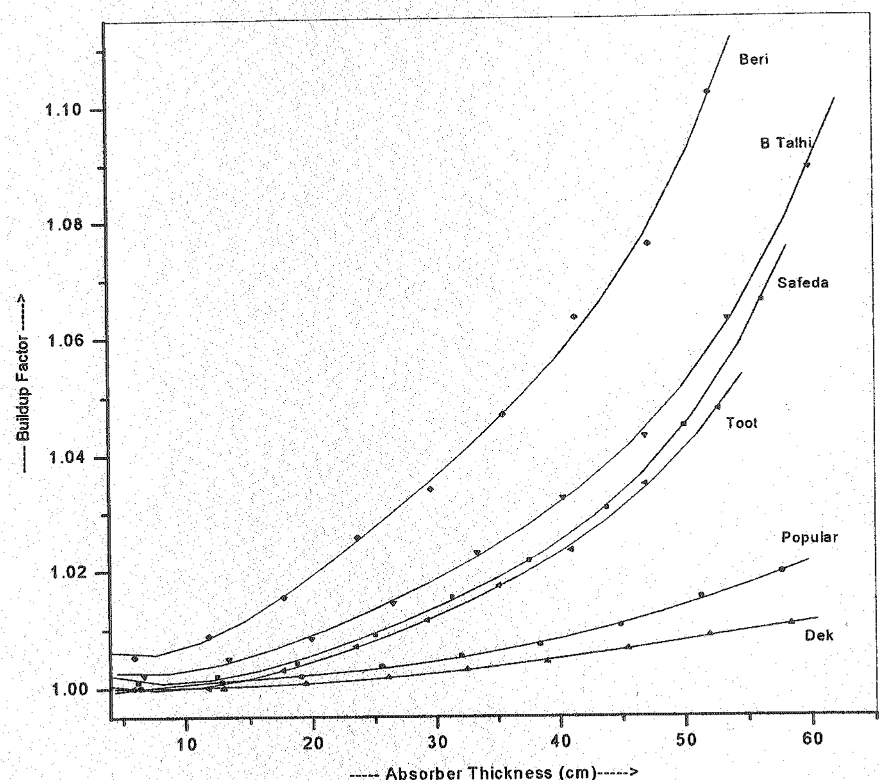

Fig. 1. Variation of build up factor of 1332 keV gamma rays with absorber thickness for a wooden samples of 28 mm collimator sizes

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