PHOTON ATTENUATION CHARACTERISTICS OF RADIATION SHIELDING MATERIALS

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INTRODUCTION

In the design and construction of installation housing high intensity radiation sources and other radiation generating equipment, a variety of shielding materials are used to minimise exposure to individual. Among the materials, lead and lead glass are best known for radiation shielding for gamma radiation due to their high density and atomic number. Commercially manufactured barium enriched cement, apart from better compressive strength, smoother surface finish and high abrasion resistance, offers adequate shielding to gamma radiation in comparison with lead. Although photon attenuation data are available in literature[1], it is necessary to test these commercially available materials experimentally for their radiation shielding efficiency before putting them in to regular use.

EXPERIMENTAL MEASUREMENTS

In the present work, photon attenuation characteristics of lead, lead glass and barium enriched cement supplied by a manufacturing firm have been studied for photons in the energy range of 364keV to 1332 keV. The monoenergetic photon radiations used for these measurements were derived from I-131, Cs-137 and Co-60 each of about 5 μci. The sources were procured as a sealed source from BARC, Trombay, Mumbai. The photon transmission measurements were done under a narrow beam counting geometry employing high resolution HPGe solid-state detector. The HP Ge detector utilized in the present work is of 30.3 cc volume and was obtained from EG&G, ORTEC USA. The detector was operated at liquid nitrogen temperature and had a good stability. The experimental set up used in the present work consists of mainly two collimators of about 12 cm. long, having internal and external diameter of 10 and 60 mm. respectively. These collimators were internally lined with 4 mm thick perspex so as to provide a scatter free collimated photon beam of 2 mm diameter with the present experimental system, it was established from the photon spectrum that the energy of transmission photons did not change appreciable due to scatter or fluorecent radiation contribution from the collimators. A provision was made midway between the collimator to introduce absorbers which were in the form of thin slabs/sheets. The entire system was arranged vertically over the HP Ge detector, ensuring that the central axis of the collimator coincided with the central axis of the detector. The source was positioned over the collimator so as to allow, a narrow well collimated photon beam from the collimator incident normally on the absorbers. The source and the detector were well aligned with the collimators. The incident energy of photon radiation from each radioactive source was known accurately from the photon spectrum taken with a callibrated gamma spectrometer. The absorbers used include thin and uniform slabs/sheets of high purity of Barite, Lead and Lead Glass. The absorbers were weighted accurately on a sensitive balance, and from their measured area the thickness proportional to the aerial density in g/cm^{-2} were determined. The absorbers having varying thicknesses of a few mg.cm^{2} and higher thicknesses were obtained by stacking them together. All absorbers were of high specified purity . Each absorber of specified thickness was interposed in the beam such that the primary photon beam was incident normally on its surface. The transmitted photon spectrum of the source used had energy resolution characteristics of the full energy absorption peak, identical with that of primary photon beam. The thickness of the absorber was increased in steps. The counts under the full energy absorption peak of the recorded photon spectrum were determined. The photon spectra were recorded several times for each additional thickness and an average of counts under the full energy absorption peak was obtained. From the transmitted (I) and the incident photon intensity (I_0), for a thickness `x' of the absorber, the photon attenuation coefficient μ_m is given by the following expression:

$$\mu_m = l_n (l_o / l)/X$$

The average number of transmitted photons through the different absorber were plotted against thickness on a graph paper with thickness (t) as ordinate and abscissa as a plot of log (N). The slope of graph gives the attenuation coefficients in cm^{-2} g.

RESULTS & DISCUSSION

The results reported here in Table-1, are the experimental values of photon attenuation coefficients (μ) determined in this work. The data of Table-I, represents actual values of photon attenuation coefficients (μ/ρ) determined experimentally at 363keV, 661keV, 1171keV and 1332keV photon energy for Barite, Lead and Lead Glass and have not been reported experimentally earlier. Theoretical values (2) obtained for the specified absorbers and photon energies have not been shown in this table. However, the values agree well with theory within range of experimental errors. The overall uncertainity of the measured values was estimated to be around 5% and had the following components: the counting statistics for I and I_o exposure measurements and thickness uniformity of the absorbers. Thus the derived values of attenuation coefficients of these materials can be utilised in compilation of shielding thicknesses for photons in a radiation facilities where these materials are to be used.

TABLE 1.ATTENUATION COEFFICIENT OF BARITE , LEAD AND LEAD GLASS FOR PHOTON RADIATIONS

Radio-Nuclide	Energy (keV)	Attenuation Coefficients (MSQ/KG)		
		Barite+	Lead#	Lead Glass#
I-131	363	0.00996	0.0183	0.01736
Cs-137	662	0.00755	0.00103	0.000944
Co-60	1171	0.00541	0.0064	0.00619
Co-60	1332	0.00504	0.0057	0.00555

+Associated Cement Company, Mumbai
Shah Corporation, Mumbai

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1. Davisson C.M. and Evans R.D.(1952), Rev. Mod. Phys.24, 79

2. Hubbel J. H., National Bureau of Standards, Washington D. C Report No.29, 1969.