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SHIELDING EFFECT OF ALUMINUM AGAINST CS-137 SOURCE, ACCORDING TO GAMMA RAY TRANSMISSION TECHNIQUE

Muttalip Ergun Turgay [a*], Berna Aras[b], Nursel Sezgin[c], Müge Şengül[b]

[a*]*Department of Electrical and Electronics, Faculty of Engineering, University of Yalova , Yalova*
*eturgay20@hotmail.com (*corresponding author)*

[b]*Department of Physics, Faculty of art and science,Yildiz Technic University, Istanbul*
bernaaras17@gmail.com, mugeseng@gmail.com

[c]*Department of Chemistry,Faculty of art and science,Yuzuncuyil University, Van*
nurselsezgin19@gmail.com

Abstract

In this study the shielding effect of the Aluminum element against radiation is referred to by using the gamma ray transmission technique. Selected gamma-ray source Cesium is monoenergytic and not necessary the activity correction due to its half-life. Absorption caused by aluminum leads to a reduction in the radiation dose exposed. In the literature, there are many studies on this technique using different materials. Our experiments were carried out with aluminum samples of different thicknesses. Density values are calculated through counts obtained using the Scintillation detector is used in order to get intensity values via counts. By increasing the thickness of the sample from a minimum of 0.49 cm to a maximum of 2.29 cm, the [I/Io] ratio is respectively; 0.8995; 0.8134; 0.7170 and 0.6413 calculated. The curve of variation of the ratio [I/Io] for different thicknesses is given in the graph. R2 value was obtained as 0.9960. The linear absorption effect is accurately observed. Another issue is; in industrial applications, using these intensity ratios; material thickness measurements can be made easily.

Keywords: Cs-137, absorption/attenuation, aluminum; gamma-transmission technique, nuclear applications

1. Introduction and literature survey

Linear energy transfer (LET) and curve of attenuation coefficient (μ) could be assessed in radiation studies generally. [1] Nuclear techniques are especially used for thickness and density measurement, material analysis, corrosion determination and viscosity measurements (M. E. Turgay, 2017). In this study, absorption effect was searched and revealed the linearity. Cesium is preferred as Gamma source due to its suitable (30 years) half life, and also avoid to activity correction. Density of aluminum is 2.70 g/cm^3. Shape of the aluminum material and Cs source were depicked on Figure- I. There are many studies on gamma ray transmission technique in the literature. Some of them will be referred to by name here. [2] Scaling studies with gamma transmission technique, T. Bjornstad, E. Stamatakis. [3] NXcom-A Program for Calculating Attenuation Coefficients of Fast Neutrons and Gamma- Rays, El-Khayatt AM. [4] Calculation of Gamma and Neutron Shielding Parameters for Some Materials Polyethylene-Based, Elmahroug Y, Tellili B, Souga C. [5] An Investigation on Gamma Attenuation Behaviour of Titanium Diboride Reinforced Boroncarbide-Silicon, Buyuk B, Tugrul AB. [6] Investigation on the Behaviours of TiB2 Reinforced B4C-SiC Composites Against Co-60 Gamma Radioisotope Source, Büyük and Tuğrul**.** [7] Cs-137 Gamma Ray Attenuation Properties of Flexible Silicone Rubber Materials, B. Büyük. [8] Comparison of Gamma Sources (Cobalt and Cesium) for Density Measurement of Metals and Alloys via Using Transmission Technique, M. E. Turgay (2021). [9] Application of gamma-ray transmission method for study the properties of cultivated soil, M. E. Medhat. [10] Gamma ray transmission technique applied to porous phase characterization of low-porosity ceramic samples, A. C. Moreire, et al. [11] Determination of Gamma Transmittance and Density Assessment for Al Doped ZnO Thin Films by Using Gamma Transmission Technique, B. Karagöz, et al. [12] Gamma-ray attenuation coefficients in bismuth borate glasses, K. Singh, et al. [13] An investigation on gamma attenuation of soil and oil-soil samples, A. H. Taqi, H. J. Khalil. [14] One of the essential resource on gamma- ray applications is G. F. Knoll' s book called 'Radiation Detection and Measurement'.

2. Material and methods

Aluminum samples were prepared as 0.49, 0.98, 1.62 and 2.29 cm thickness as ordinary material. Experimental principle schema was given in Figure-1. Source and detector are settled the opposite sides of the sample. Whenever gamma-ray interacts to material, intensity of the ray will be decreases regarding absorbance effect of the material. Absorbance effect and attenuation coefficient of the material are important to understand (LET) linear energy transfer. [15] Some portion of intensity will be absorbed by material. Decreasing intensity of gamma-ray is observed as exponential Eq-I (Földiak, 1986).

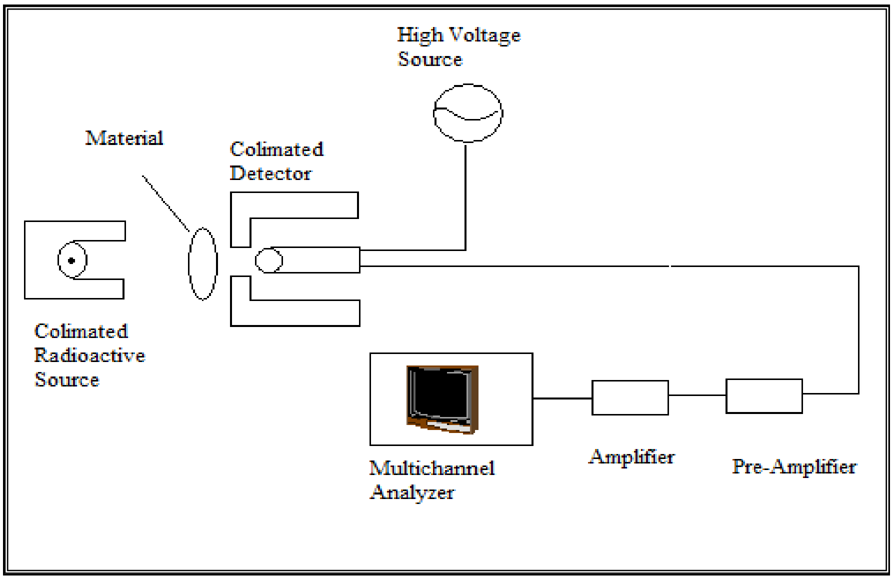

Figure 1. Gamma Transmission Technique Principle Schema

If the gamma-ray can not be completely stopped, it will pass through the material and reach to detector. This is the explanation of gamma-ray transmission technique in principly. The intensity of the radiation passing through the material decreases exponentially. [1] As a result of the measurements taken, the mass absorption coefficient was calculated using the Beer-Lambert Equation.

$$Ln\,(I/Io) = \exp[-(\mu/\rho)\rho x]$$

where μ linear absorption coefficient of material, ρ density of material, x material thickness, and $\mu_m = \mu/\rho$ here, μ_m is mass absorption coefficient (Turgay, 2017) and its theorical value is 7,47E-02 (cm2/g). Initially, intensity (I_0: radiated from source) was measured without material, then other measurements (I:detected) for different thickness of material were realized. [16] Comparison could be done by means of using both intensity (Gardner, R. P., and Ely, R. L., 1967). Our laboratuary studies were realized by Nucleus brand systems which contains NaI scintillation detector which Thallium doped. We selected the Cesium' s 662keV peak on the spectrum in order to observe the changings. Canberra brand analyzer which consist of circuits and devices (front-end Electronics), was used to image the peak intensities for each energy level.

3. Results

Io value (intensity) was obtained as 179806 cps in our laboratuary studies. Then, the gamma ray intensities measured in the detector for different thicknesses of the Aluminum sample are given in Table-1. However, the [I/Io] ratio is calculated as relative count. Finally, in the conclusion part; the linear attenuation coefficient curve for different thicknesses of Aluminum is shown in Figure- 2.

Table 1. Results of experimental measurements

Material	**Radioactive Source**	**Gamma Energy**
Aluminum	Cs-137	0,662 MeV
Thickness of M (cm)	**Count**	**Relative Count**
0	179806,25	1
0,49	161728,25	0,899458445
0,98	146254,50	0,813400535
1,62	128925,50	0,717024575
2,29	115312,50	0,641315305
Density of Aluminum (g/cm^3)	**Linear Absorption Coefficient (1/cm)**	**Mass Absorption Coefficient (cm^2/g)**
2,70	2,00E-01	7,41E-02
Experimental mass absorption C. (cm^2/g)	**Theoretical mass Absorption C. (cm^2/g)**	**% difference**

	(XCOM program)	
7,41E-02	7,47E-02	0,8

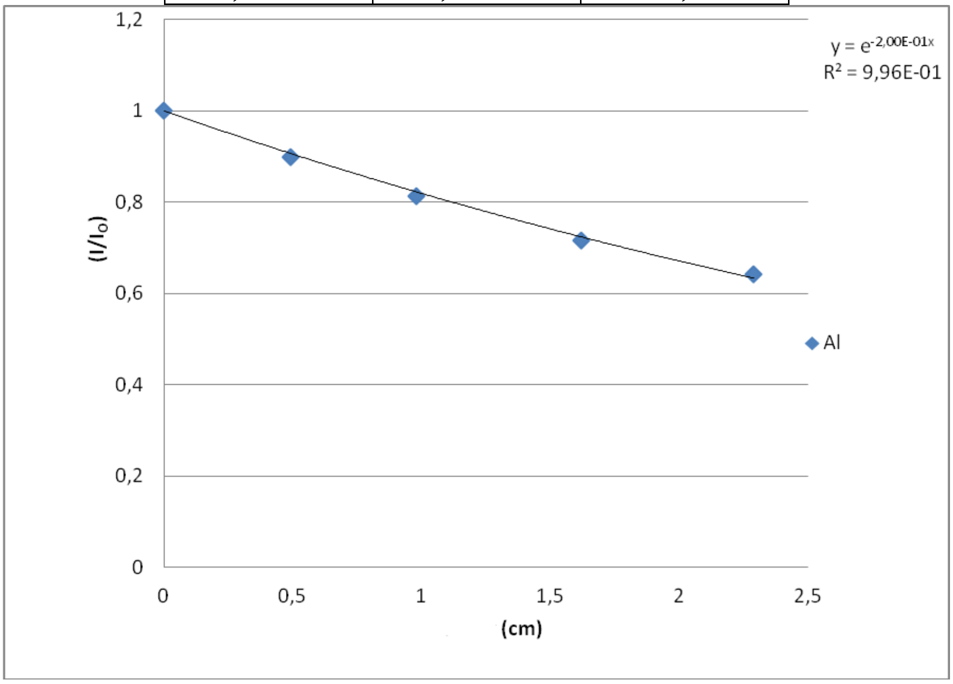

Figure 2. Variation of absorption rate according to the material thickness

4. Conclusion

By using the gamma ray transmission technique, not only attenuation properties are examined, but also density and thickness measurement studies can be performed as stated in the references. It is also used in non-destructive testing applications, too. Our results show that, depending on the thickness increase of the material; $[I/I_0]$ ratio decreases exponential. The results obtained in our study are at the expected levels. It reveals the protective effect of the Aluminum against gamma ray radiation. In addition, according to the results obtained in our study, the difference between the theoretical and experimental mass absorption coefficients was only %0.8 (Table-1). This difference is an acceptable value in industrial applications. Another important point; R^2 value is 0.9960 like depicted in Figure-1, too. These results also confirm the values obtained in our experiments. Our R^2 curve can be referenced for future studies.

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