Tikrit Journal of Pure Science
ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)
Journal Homepage: http://tjps.tu.edu.iq/index.php/j

# Investigate shielding of standard materials and glass for stopping 662 $KeV$ gamma ray penetrations.

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**ARTICLE INFO.**
**Article history:**
**-Received:** 22 / 2 / 2023
**-Accepted:** 19 / 3 / 2023
**-Available online:** 26 / 4 / 2023

**Keywords:** linear attenuation coefficient, mass attenuation coefficient, Half Value Thickness, shielding materials.

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## ABSTRACT

Calculations on shielding are required for the building of a gamma ray radiography exposure room to ensure worker exposure to radiation. A measurement used to evaluate the radiation diffusive and absorption characteristics of a medium is the linear attenuation coefficient ($\mu$). Despite the fact that, as radiation moves through a medium, its absorption is influenced by the wavelength of the radiation as well as the thickness and composition of the medium, the linear absorption coefficient is crucial in the interaction of radiation with matter. This research uses a variety of materials as a shield for a gamma radiation source of 662 $keV$ emitted by Cs-137. The results obtained using a gamma source with a scintillation counter showed that the Half Value Thickness (HVT) of glass and aluminum were 3.57 cm, and 3.39 cm while for standard materials (concrete, iron, and lead) were 2.98 cm, 1.195 cm, and 0.58 cm respectively.

## 1. Introduction

Gamma radiation is an electromagnetic radiation at the short-wave edge of the electromagnetic wave spectrum. By tradition, gamma radiation refers to radiation originating in nuclei. Gamma radiation is emitted, absorbed, and transported as separate quanta. When gamma rays impacts on a sheet of absorbing material, some of the radiation will be absorbed or scattered. As the thickness of the material is increased, the fraction of the radiation passing through the material will decrease. A specific name is given to the thickness at which half the radiation is either absorbed or scattered and the other half passes through the material, this thickness is aptly called the half thickness $X_{\frac{1}{2}}$ [1].

Gamma rays passing through a thickness of $X_{\frac{1}{2}}$ would have half the intensity, i.e. counts, as the original intensity. Needed material thickness for radiation to be attenuated by 50%, or reduced to half its initial intensity. An indicator of how readily electromagnetic radiation penetrates a substance is the attenuation coefficient. A common way to represent the attenuation coefficient is in terms of unit area per mass ($cm^2/g$). Estimating the transmission of gamma radiation through a selected thickness of shielding material or the thickness of a shielding material necessary to achieve a specified degree of attenuation may be done using the attenuation coefficient and material density [2, 3].

Gamma attenuation coefficients are inversely proportional to gamma energy and directly related to the elements from which the shielding material is made. Our findings reveal that increasing the thickness of materials reduces the intensity of gamma rays. However, it is worth noting that the quantity of absorption varied depending on the material utilized (glass, aluminum, concrete, iron, and lead), with lead having the highest absorption rate. Clearly illustrates that the linear absorption coefficient (μ) is affected by the incoming gamma ray quantity, atomic number, and absorber density [4,5].

Liner attenuation coefficient and mass absorption are two characteristics commonly utilized in the study of gamma rays. These characteristics are primarily determined by elements such as photon energy, absorbed nature, and the material through which radiation flows. The magnitude of the attenuation coefficient changes with material and density, and hence with photon energy, although particular values of the attenuation coefficient vary among materials for photons of a given energy [6].

To have a better understanding the half thickness of each of the materials were estimated. The half value thickness (HVT) of a material is the thickness at which the intensity of radiation entering it is decreased by half [7]. This study's objective was to measure the half values of all the layers as well as the linear and mass attenuation coefficients, also, this study indicates how materials could stop penetration of gamma ray at certain energy.

## 2. Materials and Method

Scintillation detector with 10% resolution, $700V\ H.V$, and $662\ keV$ energy was utilized. The detector detects gamma rays almost entirely. The Decade sealer Counter was used during the experiment to count the radiation released after traveling through the absorbers. Other materials utilized include a stand with a clamp for supporting the scintillation detector. The thickness of the absorbers was measured with a micrometer screw gauge. Glass, aluminum, concrete, iron, and lead absorbers were previously made and taken from the laboratory. The slope of the graph was calculated after exposing several absorber materials for gamma radiation of $Cs^{137}$ and measuring the linear absorption coefficient. Materials of varied thicknesses, i.e. absorbers, were each put between the Radioactive Source $Cs^{137}$ during the experiment. To monitor the radiation flowing through the absorbers, a detector (scintillation counter) was positioned immediately after the absorbers. The detector was connected to the cassy-lab to be amplified and a spectrum for the data gathered counts was created. Finally, the detector and cassy-lab were linked to a personal computer for data analysis and the creation of a spectrum to demonstrate how the spectrum varied. Refer to figure 1.

**Fig. 1: Schematic design of the experimental arrangement.**

## 3- Result and Discussion

The thickness of various materials (glass, aluminum, concrete, iron, and lead) has been varied in this work from$(0 - 7.5)cm$. An experimental result for $Cs^{137}$ gamma source has been executed. Table-1 depicts the experimental outcomes of aluminum, glass, concrete, iron, and lead. Use the measuring time of $200\ sec$ for this study because examined that measuring time of photo peak is extremely sharp give a chance for the lowest count that be considered to our work in order the rate of error decreases to minimum value.

**Table 1: Measured count for different materials with different thickness (aluminum, glass, concrete, iron, and lead) using Cs-137 gamma sources.**

| Thickness \|cm\| | Average counts per 200 sec | | | | |
|---|---|---|---|---|---|
| | Aluminum | Glass | Concrete | Iron | Lead |
| 0.0 | 7736 | 7736 | 7736 | 7736 | 7736 |
| 0.5 | 7046 | 7053 | 7122 | 5708 | 4285 |
| 1.0 | 6277 | 6239 | 6429 | 4324 | 2614 |
| 1.5 | 5591 | 5828 | 5590 | 3225 | 1256 |
| 2.0 | 5090 | 5364 | 4965 | 2350 | 728 |
| 2.5 | 4545 | 5002 | 4451 | 1697 | 474 |
| 3.0 | 4123 | 4413 | 3984 | 1396 | 207 |
| 3.5 | 3755 | 3989 | 3361 | 993 | 67 |
| 4.0 | 3383 | 3416 | 2921 | 728 | 0 |
| 4.5 | 3228 | 3033 | 2461 | 590 | 0 |
| 5.0 | 2957 | 2871 | 2119 | 398 | 0 |
| 5.5 | 2547 | 2493 | 1835 | 200 | 0 |
| 6.0 | 2119 | 2321 | 1504 | 180 | 0 |
| 6.5 | 1973 | 2146 | 1152 | 0 | 0 |
| 7.0 | 1649 | 1818 | 779 | 0 | 0 |
| 7.5 | 1591 | 1585 | 406 | 0 | 0 |

The measured count for several materials of varying thickness utilizing Cs-137 gamma sources is shown in table 1. The activity of the source will diminish as the thickness of each layer is increased until the materials have entirely absorbed the energy of gamma radiation.

From the above date that has been used to draw the diagram which is the intensity of counts and thickness of material that illustrated in Figure 2. Aluminum, glass, and concrete have roughly identical attenuation capabilities for $Cs^{137}$ gamma sources; however iron and lead have higher attenuation capabilities.

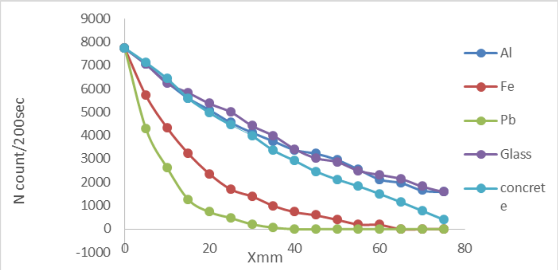


**Fig. 2: Relationship between thickness and no. of counts**

The figure 2 has been used to determine the half value layers (HVLs) for each line which are displayed in Table 2. It would be clear that each material has a specific capability to reduce the source's activity.

**Table 2: HVLs for aluminum, glass, concrete, iron, and lead.**

| Materials | HVLs \|cm\| |
|---|---|
| **Lead** | 0.58 |
| **Iron** | 1.195 |
| **Concrete** | 2.98 |
| **Aluminum** | 3.39 |
| **Glass** | 3.57 |

The linear attenuation coefficients of the samples were estimated using the equation 2. The linear attenuation coefficients of the samples were calculated using the aforementioned technique (first one calculate HVL from experimental data then compute attenuation coefficient , second one calculate attenuation coefficient from slope then analysis the HVL) and are shown in Table 3, with lead having the highest value and glass having the lowest.

The mass absorption coefficient was calculated by dividing linear attenuation to the material density [8-11]. Table-3 shows the mass attenuation coefficients for all samples that are near to each other except lead and have the greatest value

$$\mu = \frac{ln2}{HVL} \ldots(1)$$

**Table 3: Linear and mass gamma attenuation of aluminum, glass, concrete, iron, and lead**

| Materials | Density gm/cm$^3$ | Linear attenuation Coefficients \|cm$^{-1}$\| | mass attenuation coefficients \|cm$^2$/gm\| |
|---|---|---|---|
| **Lead** | 11.4 | 1.1948 | 0.1048 |
| **Iron** | 7.874 | 0.5799 | 0.07434 |
| **Concrete** | 2.895 | 0.2325 | 0.08018 |
| **Aluminum** | 2.7 | 0.2044 | 0.07570 |
| **Glass** | 2.7 | 0.1941 | 0.07188 |

We employed another way to compare our efforts by charting the figure between $Ln(No/N)$ and the thickness of our material pieces, then taking the slope. The direct value of that slope is converted into the attenuation coefficient value [12,13] are listed in Table-4.

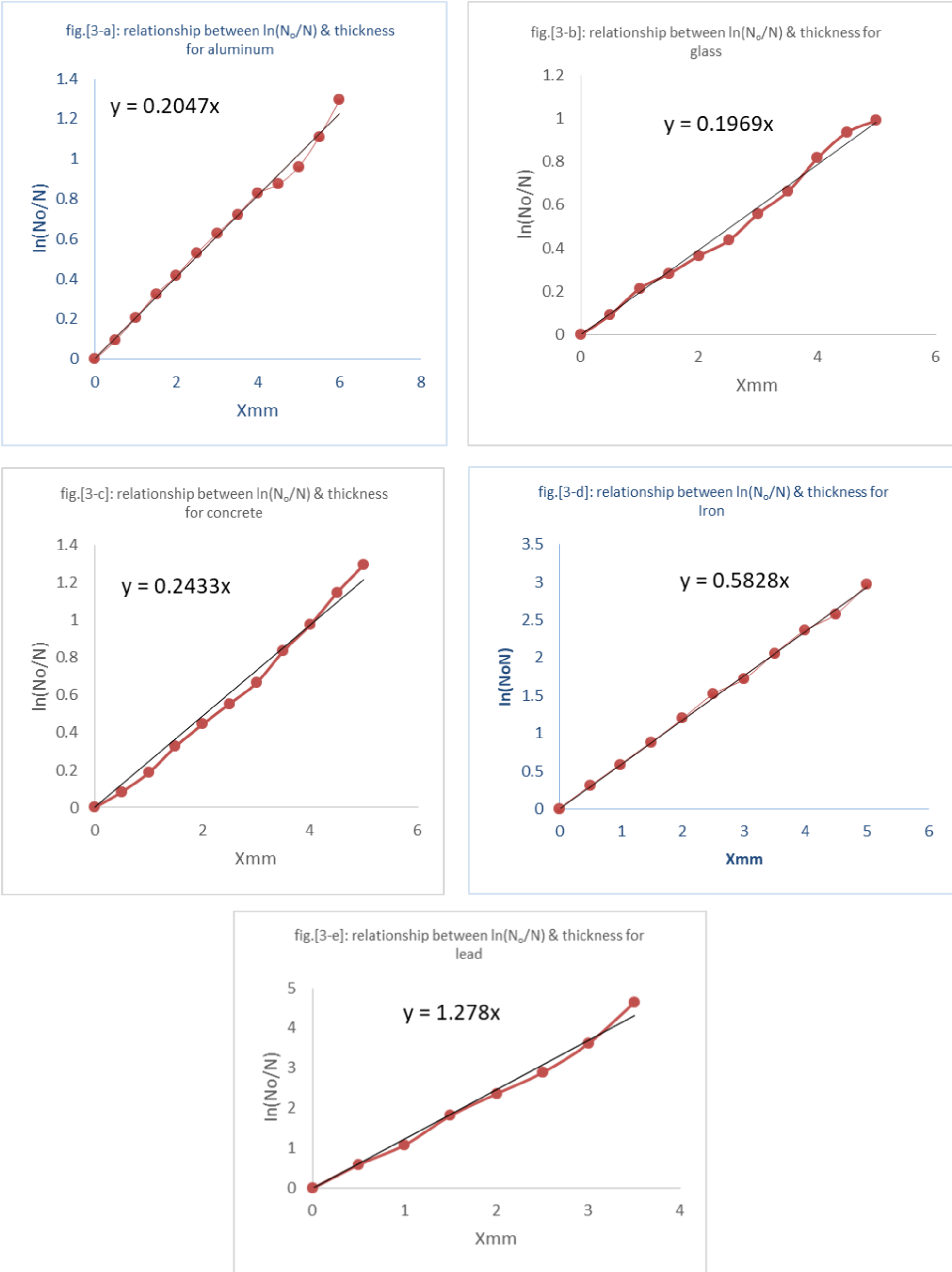


**Fig. 3: relationship between $ln(No/N)$ & thickness for materials**

Utilizing Figure 3, the attenuation coefficient for samples was calculated from this the HVLs were computed. Both of them are represented in Table 4. All samples' HVLs and linear attenuation coefficients are fairly similar for both techniques.

**Table 4: The of Linear attenuation coefficients and HVLs From slope**

| Materials | Linear attenuation Coefficients $\|cm^{-1}\|$ | HVLs $\|cm\|$ |
|---|---|---|
| **Lead** | 1.278 | 0.5422 |
| **Iron** | 0.5828 | 1.1891 |
| **Concrete** | 0.2433 | 2.8483 |
| **Aluminum** | 0.2047 | 3.3855 |
| **Glass** | 0.1969 | 3.5196 |

## 4. Conclusion

The HVLs, linear, and mass attenuation of aluminum, glass, concrete, iron, and lead materials were evaluated for Cs-137 gamma radiation. Lead has the greatest linear attenuation coefficient among of all the substances have been studied. Aluminum, glass and concrete have approximately equivalent linear attenuation coefficients, whereas iron is in the middle range of the materials. According to the findings, the attenuation coefficient are 0.194 $cm^{-1}$ ,0.204 $cm^{-1}$, 0.232 $cm^{-1}$, 0.579 $cm^{-1}$and 1.194 $cm^{-1}$ for glass, aluminum, concrete, iron and lead respectively. The shielding properties of glass, aluminum and concrete were compared to those of standard shielding (lead and iron) may be employed as radiation shielding. On the other hand, Lead is recognized to offer superior physical attributes such as hardness and strength than iron, aluminum, concrete, and glass. As a result, lead-based materials have great capability as shielding materials for gamma radiation, while according to our present work, the other materials we have worked on can be used for that purpose but with less ability.

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# دراسة تدريع المواد القياسية و الزجاج لايقاف اختراق اشعة جاما ذات الطاقة 662 كيليو الكترون فولت


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**الملخص**

حسابات التدريع مطلوبة لبناء غرفة التعرض لأشعة جاما لضمان تعرض العمال للإشعاع. القياس المستخدم لتقييم خصائص انتشار وامتصاص الإشعاع للوسط هو معامل التوهين الخطي (μ). على الرغم من حقيقة أنه عندما ينتقل الإشعاع عبر وسيط ، فإن امتصاصه يتأثر بطول موجة الإشعاع وكذلك بسمك الوسط وتكوينه ، فإن معامل الامتصاص الخطي أمر بالغ الأهمية في تفاعل الإشعاع مع المادة. يستخدم هذا البحث مجموعة متنوعة من المواد كدرع لمصدر إشعاع جاما من 662 كيليو الكترون فولت المنبعث من Cs-137. أظهرت النتائج التي تم الحصول عليها باستخدام مصدر جاما مع عداد وميض أن سمك نصف القيمة (HVT) للزجاج والألمنيوم كان 3.57 سم ، و 3.39 سم بينما بالنسبة للمواد القياسية (الخرسانة والحديد والرصاص) كانت 2.98 سم ، 1.195 سم ، و 0.58 سم على التوالي.