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Research Article

Experimental Testing of the Radiation Shielding Properties for Steel

Qays Abdul Ameer Dawood RWASHDI [1], Faez Qahtan WAHEED[2*], Kadir GUNOGLU[3], İskender AKKURT[4]

[1] Iraqi Radioactive Source Regulatory Authority (IRSRA), Baghdad -Iraq
Email: qaysdawod@yahoo.com - **ORCID:** 0000-0001-9282-5111

[2] Iraqi Radioactive Source Regulatory Authority (IRSRA), Baghdad- Iraq
***Corresponding Author Email :-** faez_radiophysics@yahoo.com- **ORCID:**0000-0002-0003-0467

[3]Isparta Applied Science Univ. Isparta-Turkiye
Email:kadirgunoglu@isparta.edu.tr - **ORCID:** 0000-0002-9008-9162

[4]Süleyman Demirel Üniv. Physics Dep. Nuclear Physics Div. Isparta-Turkiye
Email:iskenderakkurt@sdu.edu.tr - **ORCID:**0000-0002-5247-7850

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Abstract:

The development of nuclear technology and starting it to bed used in various fields made radiation part of our life. Thus protection against radiation become one of the most important topics in physics. The purpose of this work is to measure radiation shielding properties of steel sample. In this study we measured radiation shielding properties of some steels using a gamma spectroscopy system.

1. Introduction

Radiation can be defined as a simply energy in motion (particles or rays) emitted from radioactive atoms and travels through space and materials as well. It can cause ionization or excitation of the atoms. Moreover, radiation is invisible and cannot be detected by human beings senses [1]. Gamma spectrometric measurement technique and the efficiency of radiological devices are important for nuclear technology [2]. Gamma emission is a type of radioactive decay; it degenerates reactions that result in transmutation and leaves the resultant nucleus in an excited state (Figure 1) [3]. The biological hazard of gamma-ray radiation is considered to be an external hazard and can result in radiation exposure to the whole body. In order to be protected from this hazardous effect radiation shielding properties of used materials should be known. In this study the absorption coefficients of steel has been measured and also calculated.

2. Experimental Details

The frequent dense material used to attenuate the gamma rays is lead [4,5]. In this study the radiation shielding properties of Boron carbide (B_4C) powders have been tested experimentally, using a gamma spectroscopy system containing NaI (TI) detector [6,7,8].

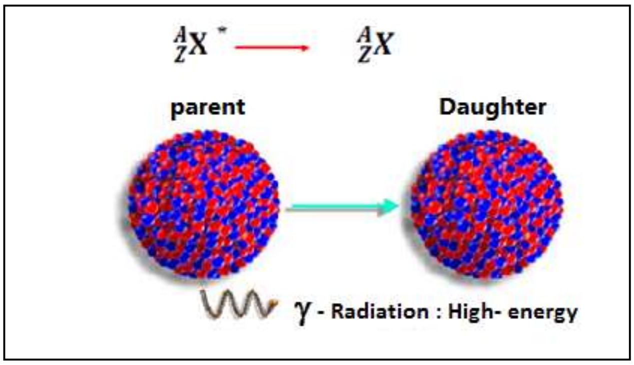

Figure 1. *The processes of gamma emission [3]*

The absorption properties of steel were measured (Figure 2). To eliminate or reduce scattering photons and background activity, the lead plate used to cover the geometry configuration (Figure 3). The obtained spectrum is displayed in Figure 4.

In the gamma ray matter interaction either a large energy transfer or even complete absorption of the incident gamma rays may occur.

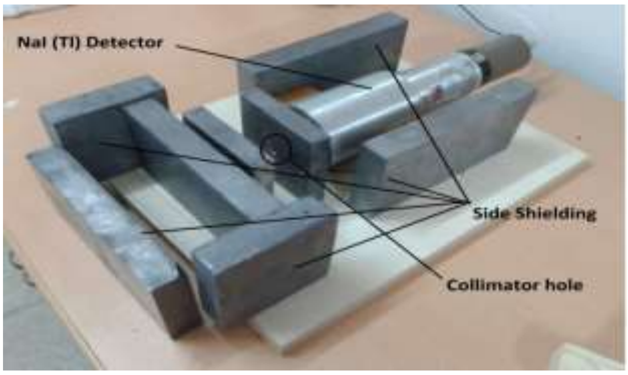

Figure 2. *The picture of the experimental setup [9]*

The linear attenuation coefficients can be obtained comparing *I* and I_o as shown in equation 1 [9]:

$$I = I_o e^{-\mu x} \qquad (1)$$

As shown in Figure 4 that the energy calibration of system was done using ^{60}Co and ^{137}Cs sources. In figure 5, the detection efficiency is displayed as a function of energy [10].

Figure 3. *Side and up shielding plate*

3. Results and Discussions

The radiation shielding properties of steels have been measured and results were compared with the calculation. The results were displayed in Figure 6. It can be seen from this figure that the calculation and measurement are in agreement. Figure 6 also shows that the linear attenuation coefficients varied with the gamma ray energies and this may be results of the different mechanism of gamma rays with the materials.

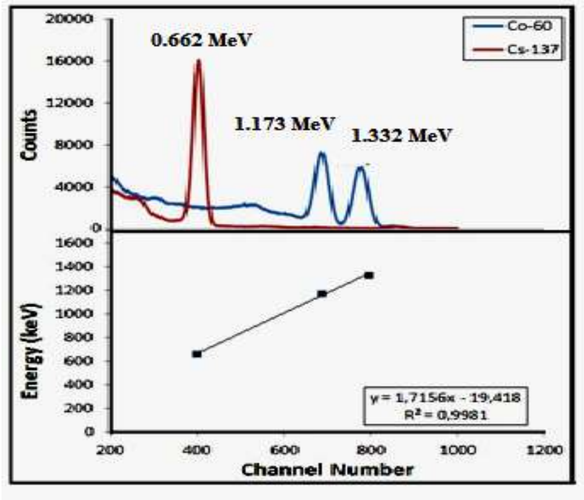

Figure 4 *Energy spectrum and related fit*

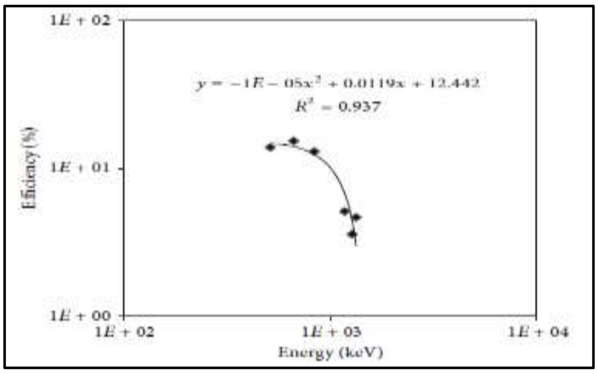

Figure 5. *NaI (Tl) detector efficiency as a function of gamma ray [9]*

4. Conclusions

The radiation shielding properties of steel sample has been calculated at photon energies of 1 keV to 100 GeV using the XCOM online calculation methods, and the experimental results were compared. It can be seen that the online calculated and the experimental measuring results are in good agreement. As well as can be concluded from this work that the linear attenuation coefficients decreased with the increasing photon energy.

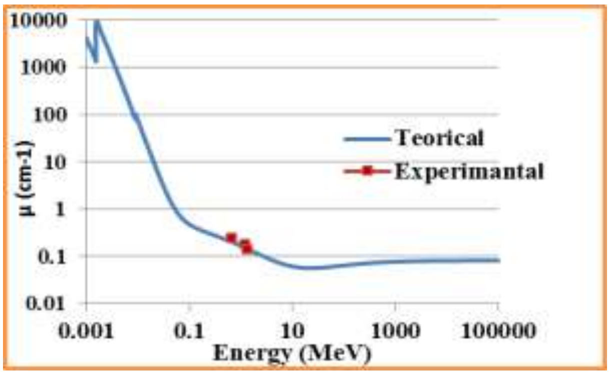

Figure 6. *The linear attenuation coefficient of composite samples as a function of photon energies*

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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- **Author contributions:** The authors declare that they have equal right on this paper.

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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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