

Study The effect of the shields movement and its thickness in detection efficiency By Using Scintillation Detector NaI(Tl)

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Abstract

In the present work, detection efficiency has been Calculated for the scintillation detector NaI(Tl) (2″ x 2″) and radioactive source Cs-137, and by using absorbent material (shield) aluminum and iron between radioactive source and detector for thickness (0.1 – 1) cm. The effect of the shield movement and its thickness and also the speed of the shield movement on the detection efficiency have been studied.

It is found that detection efficiency decrease with a moving shield and with the thickness of the shield. It is found, also that detection efficiency decrease with the speed of the shield movement for all shields aluminum and iron.

Keywords: detection efficiency, Scintillation Detector NaI(Tl) , shields

1. Introduction

Gamma detection techniques are widely used in gamma ray spectroscopy for nuclear physics, medical radiography [1, 2], neutron activation analyses [3, 4], well going [5], and study of cosmic rays. Between all of detectors used in the spectroscopy of photons, such as NaI(Tl), HPGe, Ge(Li), Si(Li), etc; the inorganic scintillator NaI(Tl) is very suitable and effective for gamma ray detection because of cheapness, applicable in medium temperature, and high density. In Gamma ray spectrometry and radiation transmission experiments, bare-surface and well-type HpGe and NaI(Tl) detectors are widely used for gamma photon detection [6,7]. When better efficiency is the most important parameter, then NaI(Tl) detector is usually preferred for gamma photon detection [8] due to its high efficiency. High detection efficiency is an important requirement in gamma ray spectrometry for good signal-to-noise ratio. Signal-to-noise ratio increases as detection efficiency increases. Detection efficiency of a detector system depends on different parameters and thus various kinds of the efficiency definitions are used to cover those parameters [9].

(i)**Absolute efficiency:** it is the ratio of the number of counts recorded by the detector to the number of gamma rays emitted by the source (in all directions).

(ii)**Intrinsic efficiency:** it is the ratio of the number of pulses recorded by the detector to the number of gamma rays hitting the detector.

(iii)**Full-energy peak (or photopeak) efficiency:** it is the efficiency for producing full-energy peak pulses only, rather than a pulse of any size, for the gamma ray.

Especially in the radioactivity measurement the absolute efficiency of the detector must be known. It is defined as the ratio of the number of counts recorded by the detector **(N_c)** to the number of radiation **(N_s)** emitted by the source (in all directions) as represented in the following formula [10].

$$\varepsilon_{abs} = \frac{N_c}{N_s}$$

2. Experimental Part

gamma rays spectrum was measured for used materials by using the system of counting and electronic analysis user in the detection of nuclear radiation and processed from the Company ((Spectrum Techniques LLC Type (UCS-30) and by using detector crystal iodide, sodium activator thallium NaI(Tl) size (2 "x 2"). and the time of aggregation used to measure the spectrum for radioactive source used is (1000) sec as shown in Figure (1) [11].

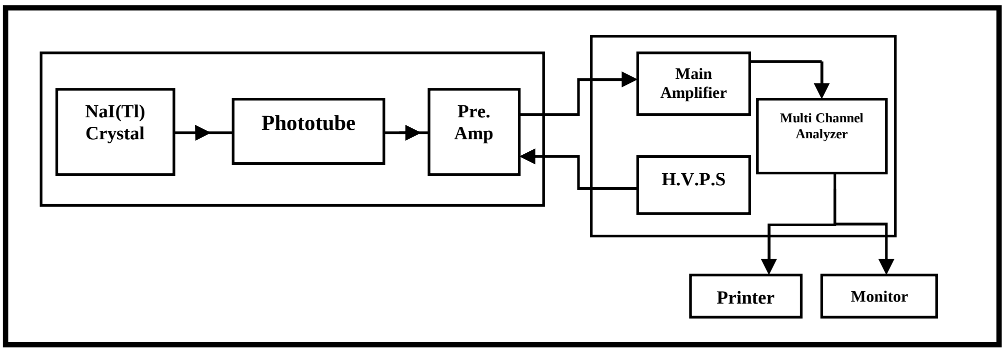

Figure (1) Shows system parts of nuclear detection

1.2. NaI(Tl) Scintillation Detector

A gamma ray interacting with a scintillator produces a pulse of light that is converted to an electric pulse by a photomultiplier tube (PMT). The PMT consists of a photocathode, a focusing electrode, and 10 or more dynodes that multiply the number of electrons striking at each dynode. A chain of resistors typically located in a plug-in tube base assembly biases the anode and dynodes. The properties of a scintillation material required to produce a good detector are transparency, availability in large size, and large light output proportional to gamma-ray energy. Few materials have good properties for detectors. Thallium-activated sodium iodide [NaI(Tl)] and cesium iodide [CsI(Tl)] crystals are commonly used, as well as a wide variety of plastics. The high Z of iodine in NaI(Tl) crystals result in high efficiency for gamma-ray detection[12].

Finally, the preamplifier receiving linear charge coming from the detector and convert it into an electrical pulse then to potential pulse, and amplify it to a level that can be fed back it to the main amplifier without deformation in capacity. Then the main amplifier amplifies the pulses that came out of preamplifier and analyzed by multi-channel analyzer (MCA), (Shaping, Filtering and Noises) Then, the analyst convert pulses coming from the main amplifier to the digital numbers by (Analogue Digital Converter) (ADC) and displayed in the form of visual images(gamma ray spectrum) by the calculator using the UCS-30 program[13].

2.2. Mechanism of the shield movement

In the current research was designed mechanical mechanism for the purpose of moving the shield. This mechanism consists of a box containing the electric motor is working to move the shield linear movement for distance (20) cm and the speed (V = 18 cm/sec) as in Figure (2).

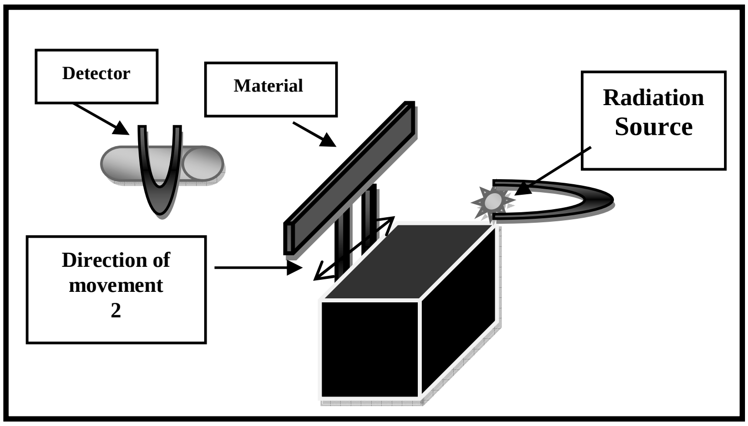

Figure (2) Shows Mechanism of the shield movement

3. Calculations, Results and Discussion

Table (1) and Table (2) shows the results were obtained in this study where the: (Thick.) represents thickness of the shield (Aluminum and Iron), (Fix. and M.) represents Detection Efficiency for NaI(Tl) in the case of the shield is fixed and moving.

Table (1) Detection Efficiency in the case of the shield (Aluminum) is fixed and moving with different thickness.

Type of material	Aluminum	
Radiation Source	Cs-137	
Thick. (mm)	Detection Efficiency %	
	Fix.	M.
1	12.8334	12.0601
2	12.1154	11.7275
3	11.6731	11.1029
4	10.9701	10.6455
5	10.6204	10.2024
6	10.5453	10.0133
7	10.2017	9.8655
8	10.1672	9.7546
9	10.0317	9.6660
10	9.8926	9.3298

Table (2) Detection Efficiency in the case of the shield (Iron) is fixed and moving with different thickness.

Type of material	Iron	
Radiation Source	Cs-137	
Thick. (mm)	Detection Efficiency %	
	Fix.	M.
1	**12.7657**	**11.7945**
2	**11.2361**	**10.6869**
3	**10.8741**	**9.8199**
4	**9.9820**	**8.9862**
5	**9.4301**	**8.7497**
6	**8.9517**	**8.2096**
7	**8.4665**	**8.0134**
8	**7.7682**	**7.2756**
9	**7.0220**	**6.5404**
10	**6.7966**	**6.3533**

In this work detection efficiency has been calculated for Thallium-activated sodium Iodide detector NaI(Tl) by using point source(Cs-137) placed in a fixed position, It was found that the detection efficiency decreased with increasing thickness of the shield and both materials (aluminum and iron) and this agreed with previous studies, in addition to that found that the efficiency of detecting decreased when you move the shield as shown in the figures (3) and (4) ,the reason for this is due to the movement of the shield lead to the dispersion part of the rays penetrating the shield and the deviation from the track away from the detector. Also, the movement of the shield led to a weakening of the cross-section for the photoelectric interaction by following the small size of exposure to photons falling during the movement of the shield.

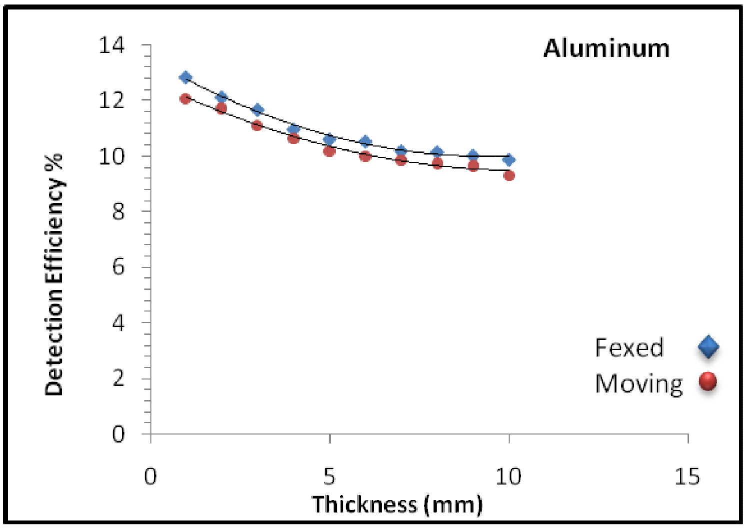

Figure (3) shows the relationship between the efficiency of detection and thickness of the shield (aluminum) and both cases (fixed and moving).

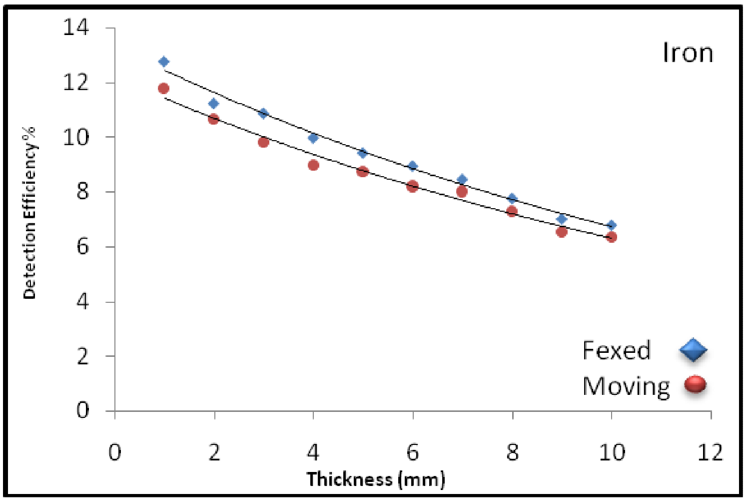

Figure (4) shows the relationship between the efficiency of detection and thickness of the shield (iron) and both cases (fixed and moving).

In case An increase in the speed of movement for the shield, has been studying the relationship between the speed of the movement of the shield and the detection efficiency for the detector, thus it has been observed that the detection efficiency decreased with increasing the speed of the movement of the shield and the relationship between them is linear relationship, as shown in Figure (5).

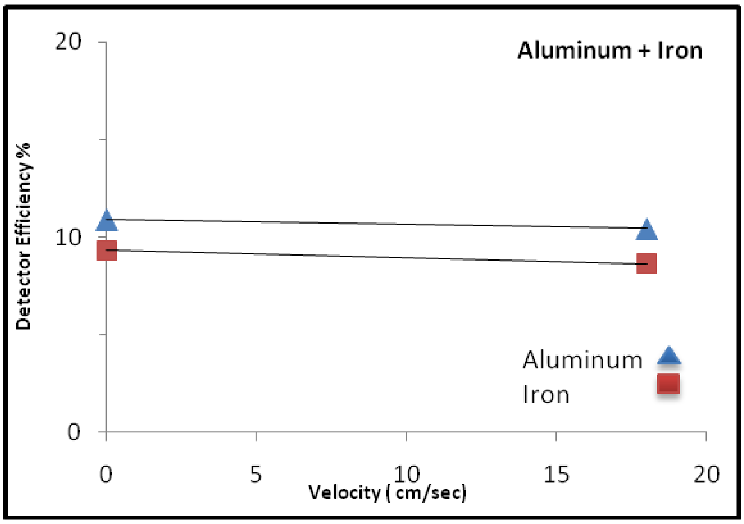

Figure (5) shows the relationship between the efficiency of detection and Velocity of the movement of the shield (iron and aluminum).

4. Calculations

Concluded from this study, a number of factors that have a direct effect on detection efficiency for radiation detectors that are used to detect radiation:-

1- Presence a shield (absorbent material) between the radioactive source and the detector.

2- Increasing the shield thickness reduces the efficiency of detection.

3- The shield movement reduces the efficiency of detection.

4- Speed increase of the shield movement reduces the efficiency of detection.

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