World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 5.218

RESPONSIBILITY OF RADIATION DETECTORS

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Article Received on 20/02/2019 **Article Revised on 14/03/2019** **Article Accepted on 03/04/2019**

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ABSTRACT

Number of detectors that can be used to detect gamma rays and x-rays. Saphymo and Berthold detectors are some of them. In this research work, a comparison study has been carried out between both detectors and efficiently and their fields of application were determined. Results showed that, Saphymo detector is more sensitive to low radiation where, Berthold detector is suitable to detect higher radiation. On the other hand, the uncertainty level of Saphymo detector was found to be better than Berthold detector.

KEYWORDS: Berthold detector, Detector, Ionizing, Radiation, Saphymo detector, uncertainty.

INTRODUCTION

Ionizing radiation has always been present in the natural environment. Sources of ionizing radiation are commonly found in water, air, soil, or manmade devices. However, ionizing radiation is situated in the electromagnetic spectrum outside the region of perception of the human eye visible region and it has no smell. Thus, it cannot be detected by the human senses. Since the ionizing radiation is not easily detected and it also possesses high ionizing power and penetration strength, it constitutes a risk to human health when it is found outside of its acceptable limits .[4] The detection of the radiation depends on its particular interaction with a sensitive material, and different types of detectors, in different physical states (solid, liquid or gas). Radiation instruments are designed with a specific purpose in mind.[6]

Radiation Detection

Detection of radiation is based on its interactions and the energy deposited in the material of which the detector is made. The ultimate goal is a formation of electron-ion pair inside the working volume of the detector because at the final stage of detection only electrically charged particles can be registered. They are collected on electrodes with the opposite charge due to voltage applied between them as shown in figure (2).

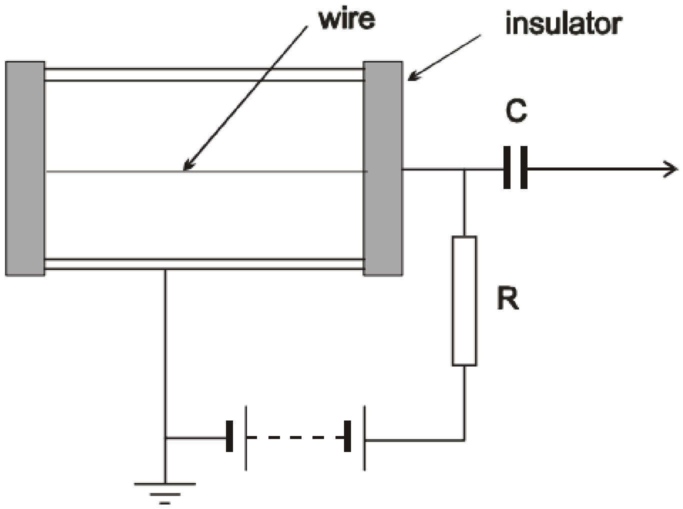

Fig. 1: Schematic diagram of detection of radiation.

The collection of electric charges created by electron-ion pairs reduces the voltage across the capacitor (C), causing a pulse across the resistor (R) that is recorded by an electronic circuit.[3] The detection is made possible by the interaction of nuclear radiation with atomic electrons directly or indirectly.[1]

The detection of the radiation depends on the particular interactions with the sensitive material, and there are three main and well-established possibilities to relate and categorize the induced radiation with the generated signal in the detector, as shown below:

1. The generated signal from the incident radiation is created by the counting of the number of interactions occurring at the sensitive volume of the detector. In this case, the detector is called counter.
2. The incident radiation generates a signal that measures the energy that has reached the detector. The detector is named spectrometer.
3. The detector measures the average energy incident on a specific point of the sensitive volume, that is, the absorbed radiation dose. Such detectors are known as dosimeters.[2]

The function of the detector is to produce a signal for every particle entering into it. Every detector works by using some interaction of particles with matter. Following is a list of the most common detector types.[5]

Table 1: Classification of detectors.

Detectors	
Electric	**Optical**
Ionization Chamber	Photographic Emulsion
Proportional Counter	Expansion Cloud Chamber
Geiger-Muller Counter	Diffusion Cloud Chamber
Semi-conductor detector	Bubble Chamber
Neutron Detector	Spark Chamber
Scintillation Counter	
Cerenkov Counter	

Saphymo and Berthold Radiation Detectors

Saphymo detector consists mainly of four components as demonstrated in figure (1) below. Devices and tools constructing this detector are:

1. X-Ray machine: output voltage 13.5 KV to 320 KV and maximum current 22.5 mA, model MGC-30, manufacture by PHILPS.
2. Radiation Source of Cesium (CS-137): serial number n40095 with activity 0.001Ci
3. Four radiation detector: Saphymo, type SPP-2-2NF, Scintillometer; SN: 992287 – 001923, SN: 992287 – 001925, SN: 00245950, SN: 03771 made in France.

Fig. 1: Saphymo radiation detector.

On the other hand, BERTHOLD detector also consists of four Germany made detectors type LB1230. These detectors are; SN: 159832 – 3351, SN: 159832 – 3328, SN: 490236 – 1535, SN: 490236 – 1529. Figure (2) below shows the Berthold radiation detector.

Fig. 2: Berthold radiation detector.

Also the detector consists of TV Camera, TV Screen, Three laser alignment, 20 mm Lead and Holders.

MEASUREMENTS AND RESULTS

This work was carried out in secondary calibration laboratory, where it was set the radiation detector by the laser beam.

The detectors were monitored inside the laboratory by the camera and TV during the irradiation.

A lead with thickness 20 mm was placed between detector and X-ray machine to attenuate the X-ray.

Finally, the detectors irradiated with the two beam of X-ray (100KV and 200KV), and beam of Gama-ray (Cs-137) 662 Kev.

Results of measurement carried out are tabulated hereunder. Table (2) below shows the Saphymo and Berthold radiation detectors average measurement at 100 KV.

Table 2: Average measurement at 100 KV.

Barthold		Saphymo		Distance (cm)	Volt (KV)
uncertainty	average measurement	uncertainty	average measurement		
3%	9.25	9%	11200	50	100
3%	8.33	11%	9875		
4%	6.6	10%	7950		
4%	5.3	12%	6350		
5%	3.55	11%	4475		
6%	2.83	13%	3525		
6%	2.43	14%	2825		
7%	1.98	12%	2200		
8%	1.4	18%	1500		
8%	1.3	10%	962.5	200	
9%	1.15	12%	857.5		
9%	1.08	12%	757.5		
9%	1.03	12%	672.5		
10%	0.93	13%	580		
10%	0.85	13%	475		
10%	0.85	18%	392.5		
12%	0.7	14%	307.5		
12%	0.65	20%	225		
13%	0.58	26%	150		

Table (3) shows the Saphymo and Berthold radiation detectors average measurement at 200 KV.

Table 3: Average measurement at 200 KV.

Barthold		Saphymo		Distance (cm)	Volt (KV)
uncertainty	average measurement	uncertainty	average measurement		
3%	7.65	9%	12300	200	200
4%	6.7	8%	11025		
4%	6.03	8%	9500		
4%	4.95	7%	8050		
5%	4.1	8%	6475		
5%	3.13	8%	4875		
6%	2.58	10%	4025		
6%	2.4	12%	3450		
7%	1.7	13%	2300		
8%	1.5	14%	1700		
9%	1.1	14%	1150		
9%	1.1	8%	892.5	380	
10%	0.95	11%	707.5		
10%	0.9	12%	537.5		
10%	0.83	13%	432.5		
12%	0.73	18%	382.5		
12%	0.65	23%	292.5		
12%	0.63	18%	202.5		

Table (4) show the Saphymo and Berthold radiation detectors average measurement at energy of Cs-137.

Table 4: Average measurement at energy of Cs-137.

BARTHOLD		SAPHYMO		Distance (cm)	Radiation Source
uncertainty	average measurement	uncertainty	average measurement		
1%	135.8	6%	14187.5	40	Cs-137
1%	86	4%	9437.5	50	
1%	60.5	6%	6512.5	60	
1%	44.6	5%	4950	70	
2%	33.4	6%	4000	80	
2%	26.5	7%	3225	90	
2%	22.2	9%	2675	100	
2%	18.6	10%	2200	110	
2%	15.5	11%	1870	120	
3%	12.8	12%	1600	130	
3%	11.7	9%	1400	140	
3%	10.1	5%	1250	150	
3%	7.6	6%	962.5	175	
4%	5.8	7%	768.8	200	
4%	4.8	11%	638.8	225	
5%	4.1	10%	525	250	
5%	3.5	11%	456.3	275	
5%	3.1	10%	435	300	
6%	2.4	9%	362.5	350	

Tables (2), (3) and (4) show that the measurement of the Saphymo detector to the same radiation source and the same conditions is greater than the measurement of Berthold detector, thus that the response of Saphymo detector is greater than the response of the Berthold detector. This difference is evident at the minimum intensities, where notes that the Saphymo detector is distinguish between small values, special recent values in the three tables, while we find the measurement of Berthold at this values is very close. Thus that is difficult to distinguish between the source intensity at this values. In other words, the Saphymo detector is very sensitive from the Berthold detector.

Graphs representing the relation between detectors measurement and inverted square distance for both detectors plotted as shown below.

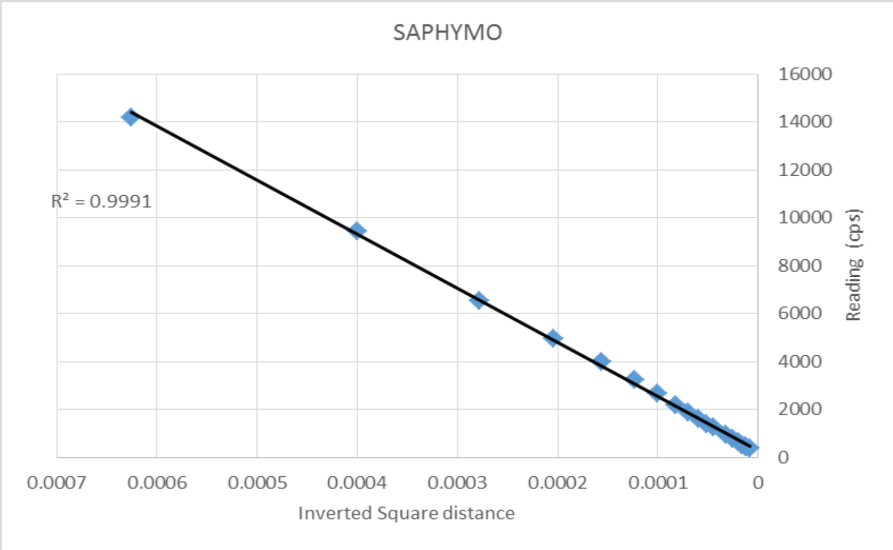

Fig. 3: Relation between the Saphymo measurement and inverted square distance.

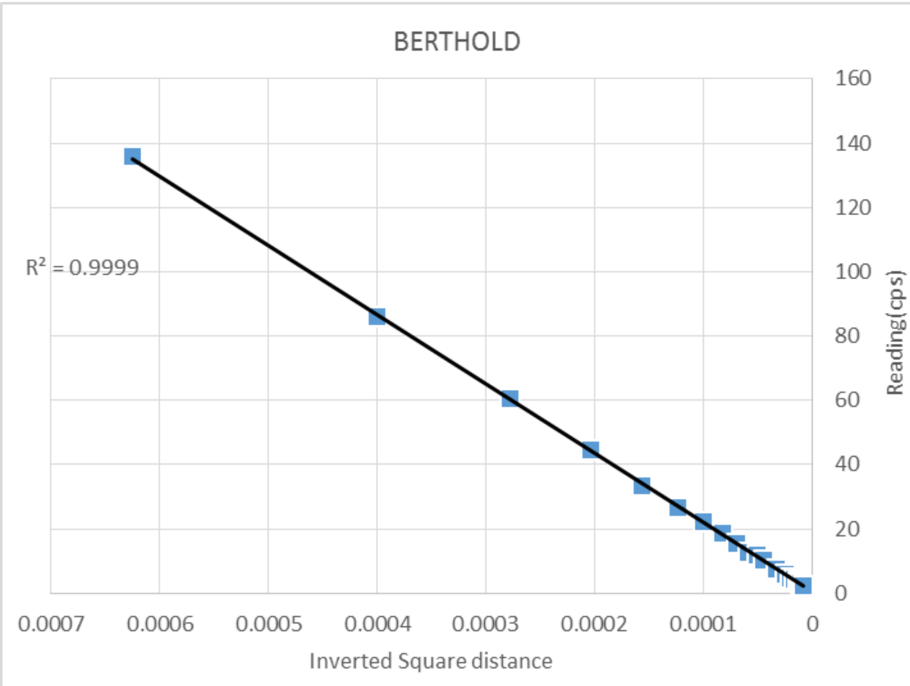

Fig. 4: Relation between the Berthold measurement and inverted square distance.

By referring to both figures (3) and (4), it can be noted that the measurement of the radiation detector Saphymo and Berthold is linear related to inverted square distance from the radiation source (Cs-137) which satisfies the inverse square law.

In figure (4) the slope of the curve can be extrapolated that the measurement of Berthold to the measurement of Saphymo that the response of the Berthold detector is very decrease at the low energy, show that in the slope of x-ray at voltage (100KV) is (0.0008), but in the slope of energy of Cs-137 (662KeV) is (0.0095), means that the response of the Berthold detector at energy of Cs-137 is greater 12th from the energy of x-ray at voltage (100KV), that to the response of the Saphymo detector.

A graph representing the relation between Saphymo and Berthold measurement and the current was plot. Figure (5) below demonstrates the result.

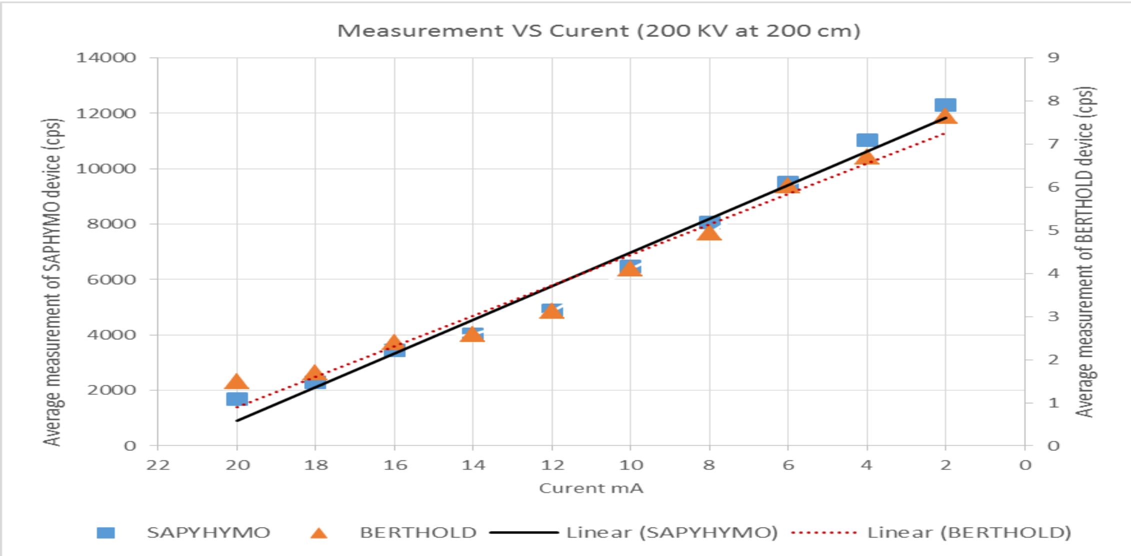

Fig. 5: Relation between the Saphymo and Berthold measurement and the current.

From figure (5) it can be noted that the measurement of the radiation detector Saphymo and Berthold are linearly related to the current of x-ray, and that is verify the linearity of the detectors with intensity of radiation.

The relation between the Saphymo and Berthold measurement at different intensities (100 KV) was investigated through figure (6).

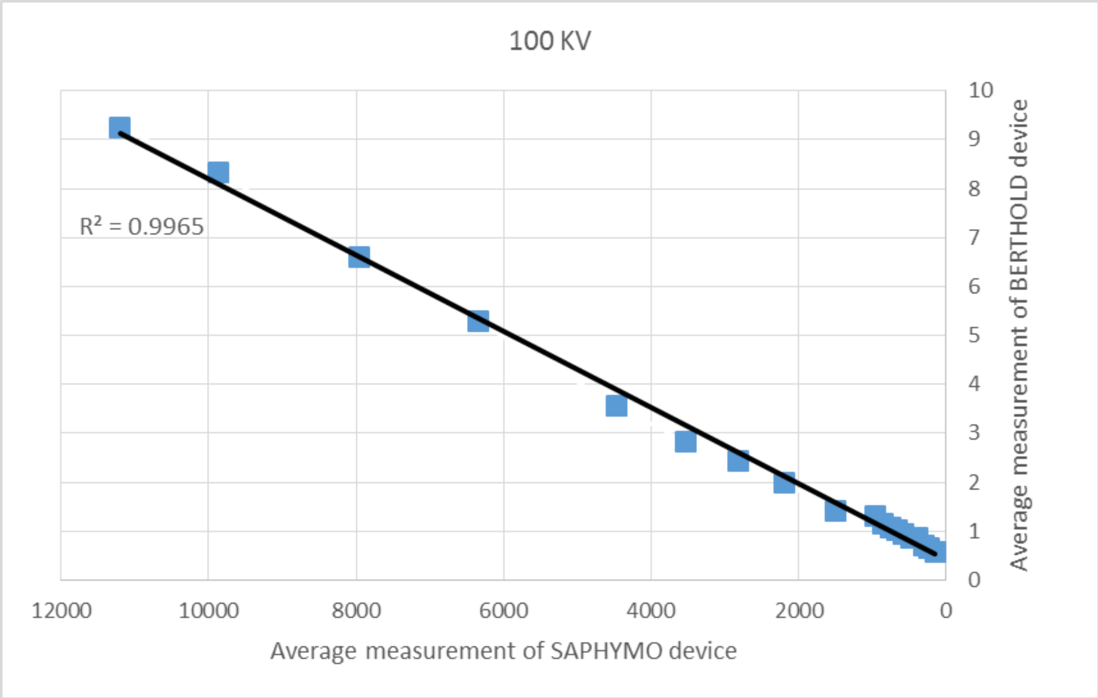

Fig. 6: Relation between the Saphymo and Berthold measurement at different intensities (100 KV).

Also, the relation between the Saphymo and Berthold measurement at different intensities (200 KV) was investigated through figure (7) below.

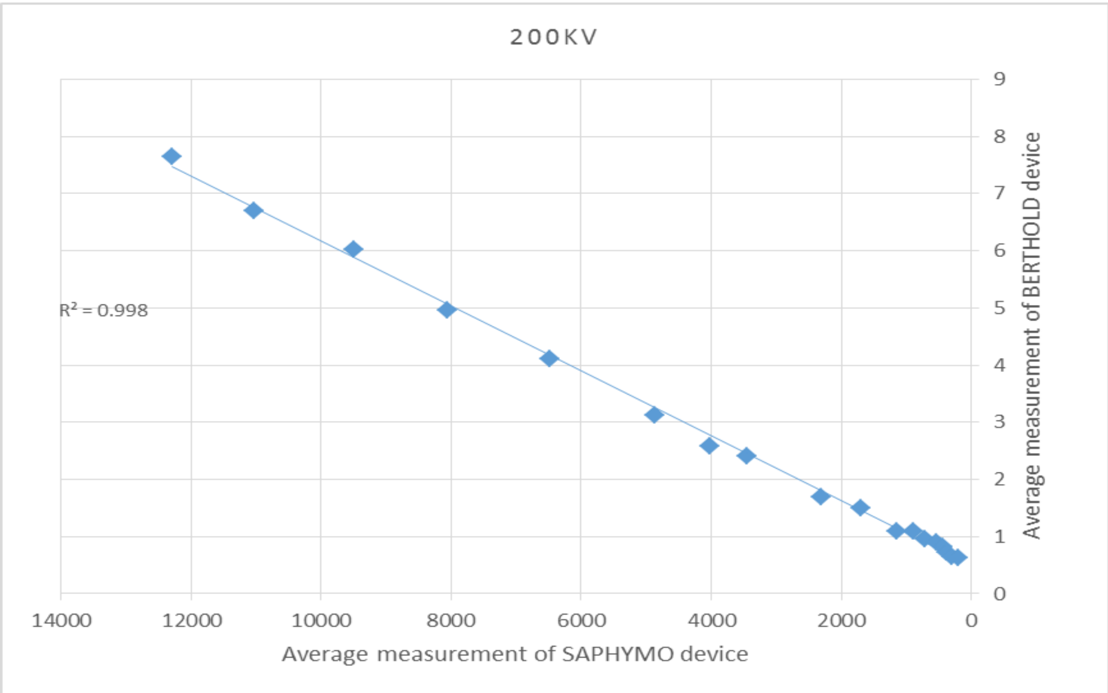

Fig. 7: Relation between the Saphymo and Berthold measurement at different intensities (200 KV).

Figure (8) hereunder shows the relation between the Saphymo and Berthold measurement at different intensities (Cs-137).

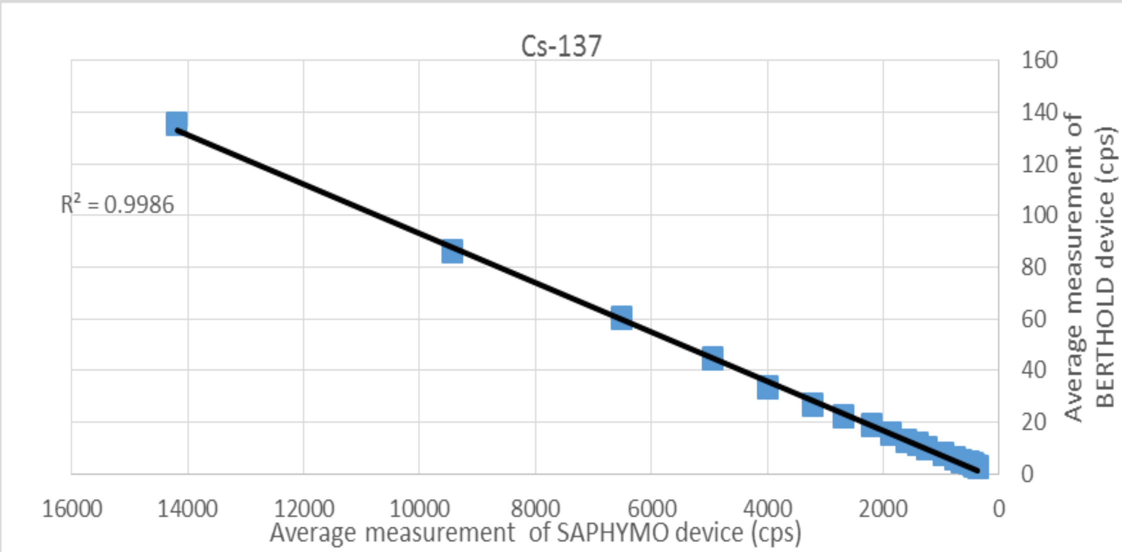

Fig. 8: Relation between the Saphymo and Berthold measurement at different intensities (Cs-137).

Finally, a graph representing the relation between the Saphymo and Berthold uncertainty measurement at different intensities (100 KV) is illustrated in figure (8).

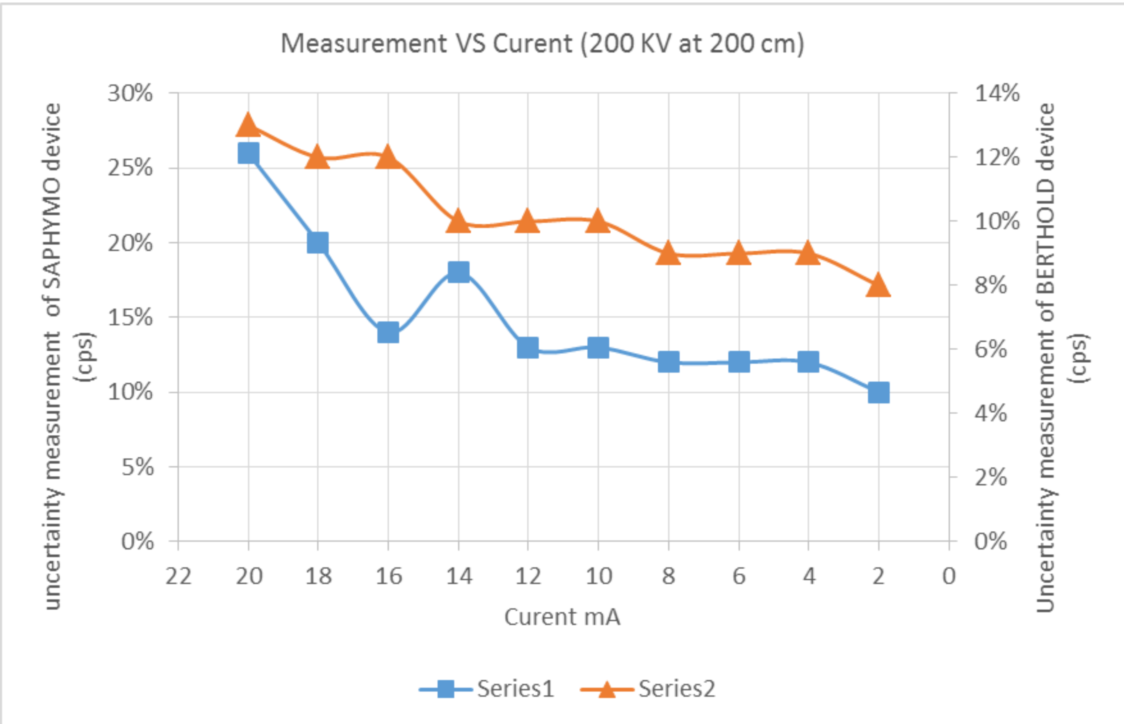

Fig. 9: Relation between the Saphymo and Berthold uncertainty measurement at different intensities (100 KV).

From fig (6), (7) and (8) show that the relationship between the measurement of the radiation detector Saphymo and Berthold, where it is clearly shown the relation is linear due to the radiation source (Cs-137) and x-ray. And any increase in the measurement of Saphymo corresponds to an increase in the measurement of the Berthold.

Finally, it can be noted that from tables (2), (3) and (4) and also from figure (9), the relative uncertainty in the measurement of Berthold detector is very small from the relative uncertainty in the measurement of Berthold detector, thus that the measurement of Berthold detector is more accurate.

CONCLUSIONS

Detectors are so important in radiometric applications to measure irradiation in a particular field. Selecting a suitable detector for a required work is necessary to preserve workers in environmental application where low radiation is expected or industrial imagery where high radiation exists.

By referring to the measurement carried out and results obtained, it can be concluded with the following points:

- Saphymo detector is more sensitive to low radiation compared with Berthold detector.
- Saphymo detector is suitable for environmental applications.
- Uncertainty level of Saphymo detector is better than Berthold detector.
- Berthold detector is suitable to be used in industrial applications.

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