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Performances of Dose Measurement of Commercial Electronic Dosimeters using Geiger Muller Tube and PIN Diode

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1. Introduction

Personal dosimeter is important radiation detection device for radiation protection by measuring radiation dose of workers in radiation facility such as nuclear power plant, hospital and radio isotope production facility. There are two categories in personal dosimeters, one is passive type dosimeter such as TLD (thermo-luminescence dosimeter) and the other is active type dosimeter such as electronic dosimeter can show radiation dose immediately while TLD needs long time to readout its data by heating process. For improving the reliability of measuring dose for any energy of radiations, electronic dosimeter uses energy filter by metal packaging its detector using aluminum or copper, but measured dose of electronic dosimeter with energy filter cannot be completely compensated in wide radiation energy region [1]. So, in this paper, we confirmed the accuracy of dose measurement of two types of commercial EPDs using Geiger Muller tube and PIN diode with CsI(Tl) scintillator in three different energy of radiation field.

2. Materials and Results

Two commercial EPDs used in these experiments had different radiation detector, Geiger Muller tube and PIN diode with CsI(Tl) scintillator. Geiger Muller tube had the special characteristics that Geiger avalanche multiplication, so, its charge signal did not contain the energy information of incident radiation. On the other hand, PIN diode had energy information of incident radiation since it was operated in ionization region. Both had energy filter with their detector package.

Table I : Activities of radio isotopes

Radio Isotope	Activity (March/2014) (kBq)
Cs-137	1763.76
Na-22	1064.89
Co-60	222.31

Table II : Dose rate and distance between radio isotope and electronic dosimeter

	Dose rate (μSv/h)	Cs-137 Distance (mm)	Na-22 Distance (mm)	Co-60 Distance (mm)
Range 1	100~200	3	1	5
Range 2	30~50	5	3	10
Range 3	5~30	10	5	20
Range 4	1~5	20	10	30

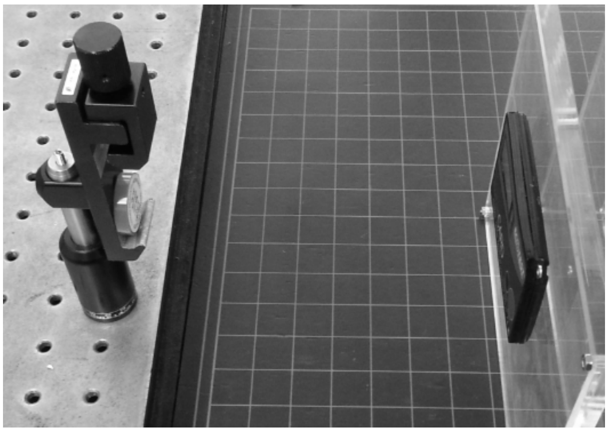

Fig. 1. Experiment setup, small disk on the left is radio isotope and black box on the right is electronic dosimeter attached on acrylic panel

We used three different types of radioisotopes Cs-137(662keV), Na-22 (511keV & 1.27MeV) and Co-60 (1.17MeV & 1.33MeV). The activities of the radio isotopes were shown in Table I [2]. The low level of dose rates and each distance between the radio isotopes and the electronic dosimeters, shown in Table II, the dose rate was decided by considering the ordinary working environment of radiation workers. The electronic dosimeters and radio isotopes were equally fixed on acrylic panel above 100mm from the wood table. All doses were accumulated in 300 seconds with ten times repetitions. The experiment setup was shown in Fig. 1.

The averages and standard error of experiment values to calculation value ratio was shown in Fig. 2. The red line(=1) means the experiment value was completely same with calculation value. The calculation values were concerned the radiation dose to human tissue with mass absorption coefficient for each radiation energy [3-4]. The differences between experiment values and calculation values became higher with increasing the radiation energy in comparison with Cs-137(662keV). But, in the results of electronic dosimeter using PIN with CsI(Tl) scintillator, there were jagged trend in whole range. So, we considered the absolute average and standard error of the difference between 1 to the experiment value and the calculation value ratio for more precise comparison. These results were shown in Fig. 3. The absolute average from Cs-137 was smallest in both electronic dosimeters. And the absolute averages were increasing in higher energy radiation, Na-22 and Co-60, because, general electronic dosimeter had

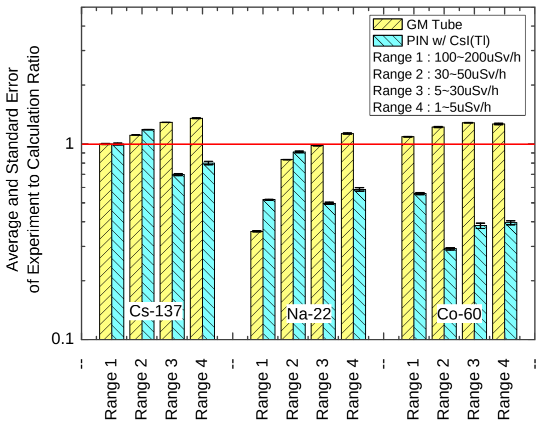

Fig. 2. Average and standard error of experiment to calculation ratio

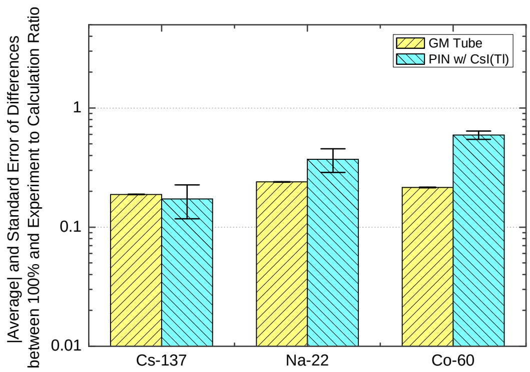

Fig. 3. Absolute average and standard error of differences between 100% and experiment to calculation ratio

conversion factor from radiation to dose calibrated with Cs-137(662keV), it was the average energy of artificial radio isotope could be exposed in radiation facility.

The absolute averages of electronic dosimeter using PIN diode with CsI(Tl) scintillator was higher than dosimeter using Geiger Muller tube. It was caused by insufficient optimization of the former's energy filter comparing with Geiger Muller Tube's. And these electronic dosimeters only applied the count method depending on energy filter without energy information of incident radiation. So, the electronic dosimeter using PIN with CsI(Tl) has the probability that it could be increased its measuring accuracy comparing with calculation value when applying the multi-level discriminator.

3. Conclusions

In this paper, we confirmed the accuracy of dose measurement for two different commercial electronic dosimeters using Geiger Muller tube and PIN diode with CsI(Tl) scintillator. The experiment results for Cs-137 was almost similar with calculation value in the results of both electronic dosimeters, but, the other experiment values with Na-22 and Co-60 had higher error comparing with Cs-137. These results were caused by optimization of their energy filters. The optimization was depending on its thickness of energy filter. So, the electronic dosimeters have to optimizing the energy filter for increasing the accuracy of dose measurement or the electronic dosimeter using PIN diode with CsI(Tl) scintillator uses the multi-channel discriminator for using its energy information.

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