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Stability Evaluation of Scintillation Dosimeter with the Same Geometry as an Ionization Chamber

Sangmin Lee [a], Junesic Park [a], Jaebum Son [a], Dong Geon Kim [a], Tae-Hoon Kim [a], Yong Kyun Kim [a*], Hyun-Tai Chung [b]
[a]*Department of Nuclear Engineering, Hanyang University, Seoul, Korea*
[b]*Seoul National University College of Medicine, Seoul, Korea*
[*]*Corresponding author: ykkim4@hanyang.ac.kr*

1. Introduction

One method of determining the absorbed dose for high energy photon and electron beams of radiation therapy devices is to measure the absorbed dose to water with an ionization chamber. The cavity volume of the ionization chamber is 0.1 - 1 cm^3. Usually only the absorbed dose for one point can be measured. Therefore, it is difficult to measure the total absorbed dose for a medium with a relatively large volume [1].

We are working on a study that produces a tumor-like scintillator of the patient with 3D printer and measures the treatment dose of gamma knife. To do this, first a scintillation dosimeter with the same shape as an ionization chamber should be produced and a calibration factor must be found by measuring radiation dose at a standard radiation field. In this study, we made a scintillation dosimeter and confirmed the stability of the signal at the laboratory level.

2. Methods and Results

2.1 Experimental Setup

The DLP 3D printer (Asiga Pico2 HD) was used to print scintillator and kit of the same shape as the farmer type ionization chamber (PTW30001). We used 3D printed scintillator resin developed by our laboratory. The scintillation light produced under the gamma source was transmitted through the 35 cm optical fiber (2000μm with 1 Fiber, Optical Grade Plastic Light Guide, Edmund Optics) and measured the signal using the PMT (H10720-110, Hamamatsu). The charge of the PMT was recorded by the electrometer (Keithley 6517A). Fig. 1 shows a schematic diagram of the scintillation dosimeter for comparison with the ionization chamber. Fig. 2 shows a photograph of the scintillation dosimeter with the same geometry as the ionization chamber.

2.2 Linearity and reproducibility

In order to determine the energy linearity, the charge was measured five times every 60 seconds under the source of Cs-137, Na-22, Co-60, respectively. The measurement data are shown in Table 1. The result of the linear fitting is shown in Fig. 3, with R-square of 0.988 and adjusted R-square of 0.977. Although linearity is not ideal, it can be determined that the R-square value shows a sufficient linear relationship.

To verify the reproducibility of the measurement system, five sets (one set: five times every 60 seconds) were recorded under a Co-60 source. After one set of measurements, the source was removed and placed again after 5 minutes to measure the next set. The measurement data is shown in Table II and Fig. 2. The fractional standard deviations for each set of experiments were less than 1.2%, but that for all experimental data was 1.64%. It is considered that the fractional standard deviation of the total data has increased due to the difference in the stabilization time of measurement and the changes of the external environment in each set.

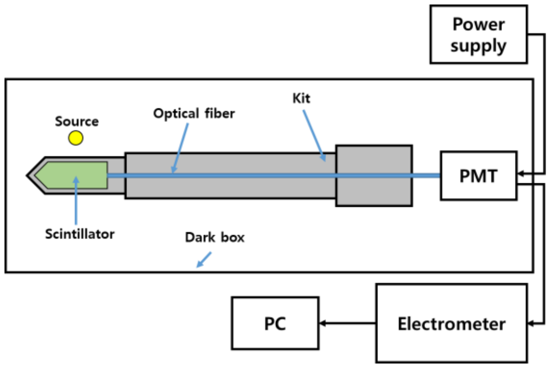

Fig. 1. Schematic diagram of experimental setup of the scintillation dosimeter system.

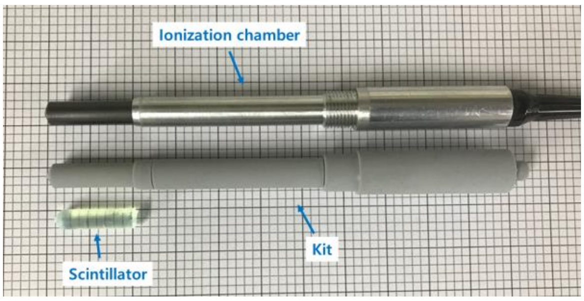

Fig. 2. Photograph of the ionization chamber and the scintillation dosimeter.

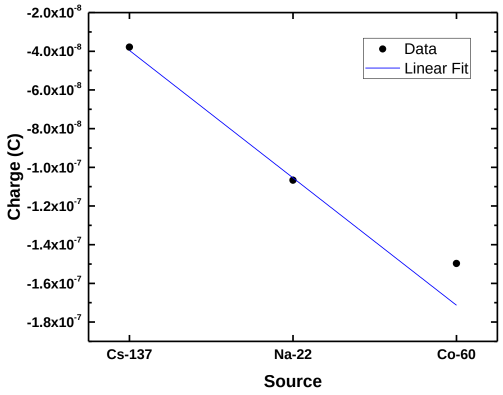

Fig. 3. Charge value and linear fitting of the system measured under three sources (Cs-137, Na-22, Co-60).

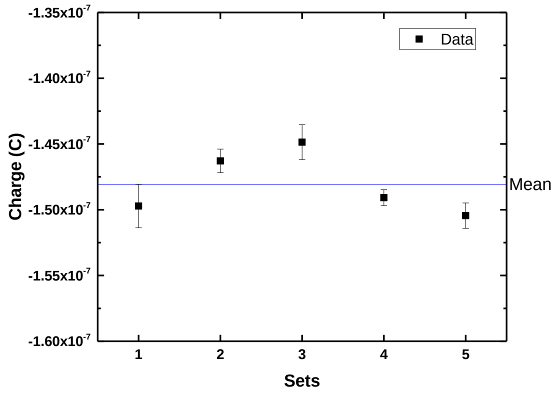

Fig. 4. Charge value of the system measured under Co-60 in order of each set.

Table I: Measurement data for determining energy linearity.

Source	Mean (Coulomb)	Standard deviation	Fractional standard deviation (%)
Cs-137	-3.79E-8	4.67E-10	1.23
Na-22	-1.07E-7	2.77E-10	0.26
Co-60	-1.50E-7	1.66E-9	1.11

Table II: Measurement data for reproducibility evaluation.

Source	Set	Mean (Coulomb)	Standard deviation	Fractional standard deviation (%)
Co-60	1	-1.50E-7	1.66E-9	1.11
	2	-1.46E-7	8.98E-10	0.61
	3	-1.45E-7	1.33E-9	0.92
	4	-1.49E-7	6.06E-10	0.41
	5	-1.5045E-7	9.68E-10	0.64
	1-5	-1.48E-7	2.42E-9	1.64

3. Conclusions

As a preliminary study to obtain the calibration factor between the ionization chamber and the scintillation dosimeter, we confirmed the stability of the measurement system. The R-square value of the linear fitting is 0.988 and adjusted R-square value is 0.977, which is considered to have energy linearity. The fractional standard deviation of the measurement data for the reproducibility verification was 1.64%. It is necessary to further reduce the resulting value by improving the system and stabilizing the measurement environment.

REFERENCES

[1] TASK GROUP 21, RADIATION THERAPY COMMITTEE, AAPM. A protocol for the determination of absorbed dose from high-energy photon and electron beams. Medical Physics, 1983, 10.6: 741-771.