The Performance Assessment of the Detector for the Portable Environmental Radiation Distribution Monitoring System with Rapid Nuclide Recognition

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1. Introduction

Immediate and overall grip of the environmental radiation distribution is important in the radiation emergency to protect the public from the radiation exposure. For it, developed has been the portable monitoring system with nuclide recognition which can display the distribution of overall environmental radiation and analyze it as soon as measurement is finished in any area, where the radiation distribution information should be shared simultaneously between on-site and control office [1, 2]. The environment radiation distribution monitoring system measures the radiation using a portable detector and display the overall radiation distribution. Bluetooth and RS-232 communications are used for constructing monitoring system. However RS-232 serial communication is known to be more stable than Bluetooth and also it can use the detector's raw data which will be used for getting the activity of each artificial nuclide. In the present study, the detection and communication performance of the developed detector with RS-232 method is assessed by using standard sources for the real application to the urban or rural environment.

2. Methods and Results

2.1 Specification of Detector

The mobile gamma radiation detector which is used for the radiation distribution monitoring system is represented in Fig. 1 [3].

Fig.1 The detector which is used for radiation distribution monitoring system

The main characteristics of the detector which is used in this system are as follows;
Detector is stand-alone type with the real time environmental radiation dose rate measurement and can be stored at portable backpack. It can report GPS coordinate and radiation dose rate per detecting time. 3 inch × 3 inch NaI(Tl) scintillator is used and detector has the function identifying of natural and artificial radionuclide in real time. The detector resolution is 7.5% (@662keV peak of ^{137}Cs). The resolution is calculated by using the equation that FWHM divided by the energy of ^{137}Cs. The detector is electronic device and detector all in one where it uses MCA and preamp. It has its own charging backup battery whose operating time is longer than 5 hours. Main specifications of the mobile gamma radiation detector are as follows. Range of dose rate is 0.011 μSv/h to 30 μSv/h and energy range is 80 keV to 3 MeV. High voltage is up to 1 kV (@1 mA). The kinds of communications which the detector uses are Bluetooth module, GPS included, RS-232 interface. The detector is waterproof, plastic resin cladding and can be operated in the range of -25 ~ 50 degree in centigrade. The battery for backup with lithium ion type is 7.2 V / 6.6 A. The detector size is 90 mm of diameter × 530 mm of length.

2.2 Data Acquisition

Conventional communication between portable detector and lab top in 'Portable Environmental Radiation Distribution Monitoring System with Rapid Nuclide Recognition' is based on Bluetooth. Bluetooth and RS-232 serial communication have same 115200 baud rate. However Bluetooth communication can be affected by electromagnetic waves or environmental condition. Therefore, data can be lost and thus the measurement uncertainty can caused. Also it is hard to treat the raw detected data because Bluetooth communication can just share dose rate value. Therefore, RS-232 which is a kind of serial communication is used for the required data acquisition. Commercialized program of MATLAB is used for the way to serial communication. Many commands such as serial, fopen, fclose… are used for getting the raw data from detector.

2.3 The Linearity Assessment of the Detector

The performance of the radiation distribution monitoring system was tested by using typical artificial radionuclide sources of ^{137}Cs and ^{60}Co.

Table I: Example of "MSG" communication command for used detector

order	byte	Description	remark
0	1	':'	MSB first
	1	'M'	
	1	'S'	
	1	'G'	
1	1	String 1st character	MSB first
	-	String (n-1) character	
	-	String n character	
	1	';'	

First of all, the ^{137}Cs and ^{60}Co sources were made at 1995.11 and 2011.10 respectively and both radioactivity was 0.1 μCi at that time. Experiment was carried out at 2014.04. The current radioactivity can be calculated considering the half-life of each nuclide. Therefore current radioactivity of ^{137}Cs and ^{60}Co is 0.0679 μCi and 0.0720 μCi respectively.

Second, the relation between the dose rate and radioactivity was analyzed. The detector produces output value as dose rate unit such as μSv/h. Detector's output is based on linearity between dose rate and total count rate. The numerical values which were used for linearity assessment was represented in Table II.

Table II: Data for linearity assessment

Dose Rate (μSv/h)	Total Count Rate(cps)
1	211
3	625
7	1351
9	1792
15	2954

Fig.2 shows the result of the count rate according to the change of the dose rate.

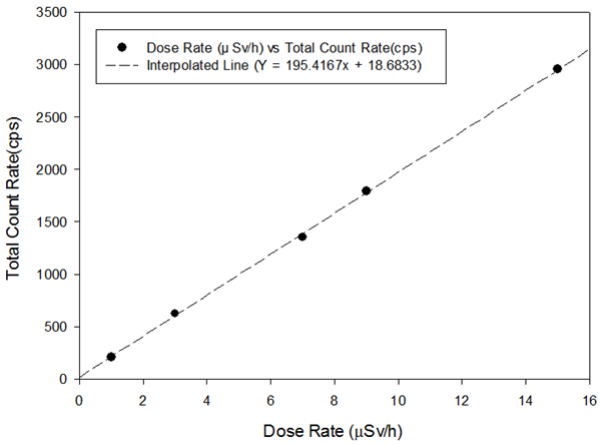

Fig.2 The relation between the total count rate and dose rate

In Fig. 2, the total count rate is linearly proportional to the dose rate where the correlation coefficient, r^2, is 0.9996. The process to obtain data is divided into two. First one is to get the value of current activity of disk sources. The ^{137}Cs and ^{60}Co sources were made at 1995.11 and 2011.10 respectively and both radioactivity is 0.1 μCi. Experiment was progressed at 2014.04. So the current radioactivity can be calculated by using the half-life of each nuclide; (^{137}Cs: 33 years, ^{60}Co: 5.27 years). Therefore current radioactivity of ^{137}Cs and ^{60}Co is 0.0679 μCi and 0.0720 μCi respectively. Second one is change the dose rate to radioactivity value. The detector which was used in the measurement produces output value as dose rate unit such as μSv/h. The detector's output has the linearity between dose rate and total count rate as shown in Fig. 2. Therefore, dose rate value can be changed to total count rate. The efficiency of detector is about 7%. Therefore, the dose rate is calculated as radioactivity. In the case of ^{137}Cs, the maximum dose rate value is 0.8068 μSv/h. From the relation between dose rate and count rate in Fig. 2, total count rate is 176 cps by calculation. Considering the detector efficiency, finally the value of 2519 Bq is obtained. In the case of ^{60}Co, the maximum dose rate value is 0.853 μSv/h and total count rate is 18.7 cps. At the same way, the radioactivity of 2648 Bq is obtained. Comparing the value of the measured activity and the calculated current radioactivity of the sources, the differences are 0.0002 μCi and 0.0004 μCi in the activity and 0.2 % and 0.4 % in the relative errors for ^{137}Cs and ^{60}Co, respectively. The measurement was in good agreement with the calculation.

2.4 Application Method of Detected Data

Quadratic differential peak search method of Mariscotti [4] is used for application of raw data from detector. Equation (1) is fundamental equation of peak search. This equation can be used for peak search by using extra equations.

$$-S_i = (N_{i+1} - N_i) - (N_i - N_{i-1}) \qquad (1)$$

After peak search, the peak area can be calculated. The peak is consisted of many parts. Fig.3 [5] is the example of classification of detected peak. The 'S' part has relation between activity. So many consideration process are needed to get the area of 'S'.

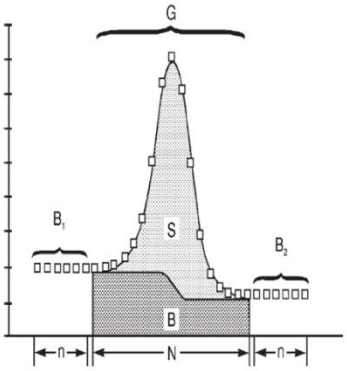

Fig.3 Classification of detected peak

Following these processes of own algorithm such as peak search, calculation of background and peak area and so on, the radioactivity of each radionuclide is calculated. It is used for dose rate calculation directly.

3. Conclusions

Assessment of the detector for the portable environmental radiation distribution monitoring system with rapid nuclide recognition was carried out. It was understood that the raw data of detector could be effectively treated by using RS-232 method and the measurement showed a good agreement with the calculation within the relative error of 0.4 % in maximum. It was expected that the detector with RS-232 communication could be used to measure the dose and radioactivity directly in the portable environmental radiation distribution monitoring system with rapid nuclide recognition.

REFERENCES

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