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Performance Characteristics of the Portable Thyroid Monitoring System

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1. Introduction

^{131}I is radionuclide of major concern under a nuclear reactor accident, and it will be concentrated in the thyroid of the exposed people for at least a brief period after inhalation [1]. The ability to screen large numbers of people who may internally contaminated with ^{131}I will be necessary so that medical intervention can be employed if needed [2]. Considering the time constraint imposed under emergency situations and the potential size of population demanding thyroid monitoring, a large number of efficient thyroid monitors should be prepared beforehand. Therefore, the portable thyroid monitoring system to be used for the estimation of intake of ^{131}I in a nuclear emergency was developed in NREMC [3]. After construction of the thyroid monitoring system, performance characteristics of the system were evaluated in this study.

2. Methods and Results

The thyroid monitoring system consists of NaI(TI) detector, a shadow shielding, a supporting table and a computer as shown in Figure 1. This system has advantage of moving easily and can acquire spectrum and activity by simply connecting the system to the notebook. Also it is possible to conveniently adjust the distance and the height of the system to the patients.

Fig. 1. Portable thyroid monitoring system

2.1 Calibration for Emergency Situation

In emergency situation, it is necessary to confirm the operation of the system anywhere, anytime. Therefore, a simple calibration method without neck phantom is needed in a nuclear emergency. Energy and efficiency can be calibrated using the volume source or point source of radionuclides having analogous energy and a longer half-life. The ratio of the counting efficiency by phantom measurements to that of the volume source or point source measurement becomes the efficiency correction factor (ECF) [4]. After the ECF calculation is completed, the results are retained for an emergency. The efficiency correction factors for volume source and point source are shown in Figure 2. The radionuclides of volume source are ^{109}Cd, ^{139}Ce, ^{113}Sn, ^{137}Cs, ^{60}Co and ^{88}Y. In the case of point source, the radionuclides are ^{60}Co, ^{109}Cd, ^{133}Ba and ^{137}Cs ranging from 88keV to 1332keV.

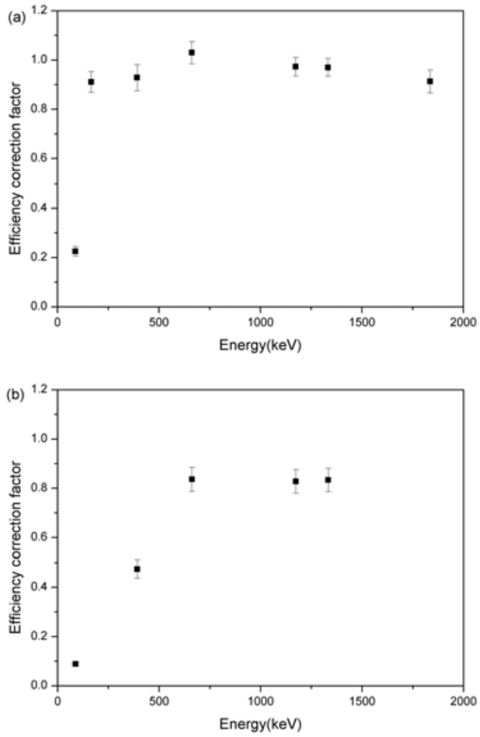

Fig. 2 Efficiency correction factor: (a) volume source measurement, (b) point source measurement

2.2 Minimum Detectable Activity (MDA)

The required sensitivity of the system varies over a wide range depending in the nature of the contamination and on the purpose of the investigation. Therefore, it is necessary to establish a detection limit based on the characteristics of the system in question to effectively assay radioactivity. Although many definitions have existed for this limit, the minimum detectable activity (MDA) can be best described as the smallest amounts of activity that can be distinguish from background, given a certain confidence level.

The MDA of portable monitoring systems developed in several countries are listed in Table 1. The MDA of the system varies according to detector type, system type, measurement distance and counting time.

Table I: MDA of several thyroid monitoring system

Institute	Detector	Distance(cm)	Time(s)	MDA(Bq)
STUK	NaI(TI) (1″×1″)	7	100	330
			600	120
CLRP	NaI(TI) (3″×3″)	15	3000	30
NRPB	HPGe	0	600	20
NREMC	NaI(TI) (2″×2″)	10	600	350

2.3 Measurement of ^{131}I

To verify the ability to measure ^{131}I of the thyroid monitoring system and to investigate the errors by the displacement of detector, measurements using IAEA/ANSI thyroid calibration phantom compared with MCNPX simulation as shown in Figure 3 and 4. The activity of 20ml vial is 9.3×10^4Bq and counting time is 1800sec. As shown in figures, the measurement activities of ^{131}I well agree with the calculated values.

When the limit of deviation for the horizontal displacement is 2cm at a 10cm distance, the range of errors is from –1.25 to –1.36%. Assuming the vertical displacement changes from 0 to 2cm at a 10cm distance, the error is –3.68%.

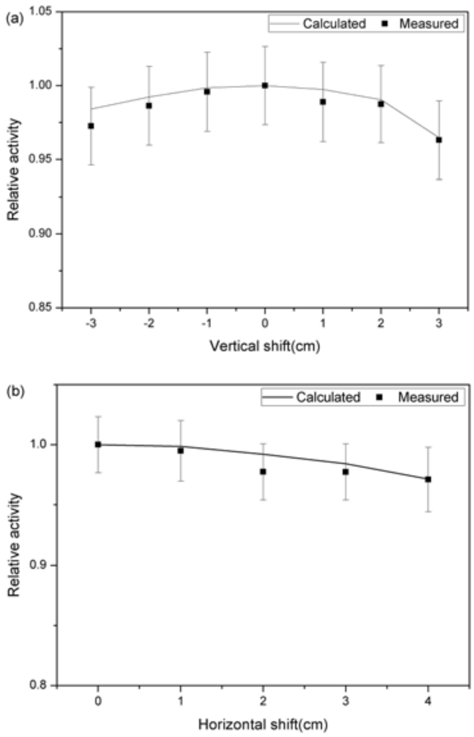

Fig. 3. Relative activities of ^{131}I according to detector offset: (a) vertical shift, (b) horizontal shift

The distance "neck-detector" is changed from –1 to 1cm at a 10cm distance; the range of errors is from –3.53% to 6.57%. The range of errors is from –3.76 to –1.17% when the limit of deviation for detection angle is from –20 to 20° at a 10cm distance.

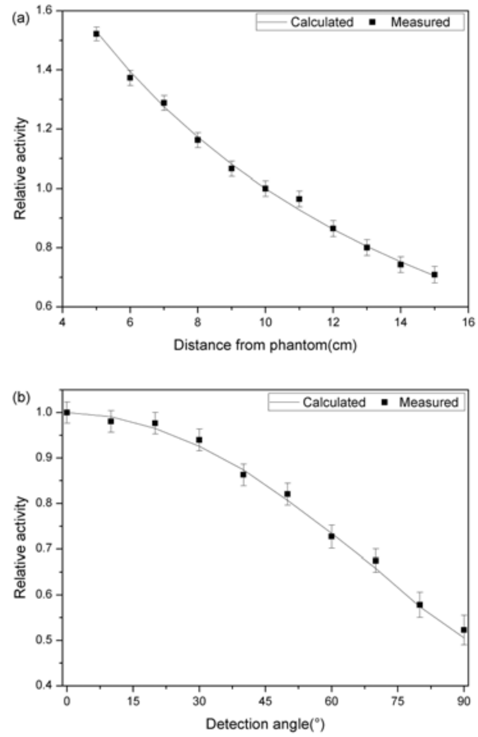

Fig. 4. Relative activities of ^{131}I according to (a) the distance from the phantom to the detector and (b) the detection angle

3. Conclusions

Performance characteristics of the thyroid monitoring system developed in NREMC were evaluated. This system can be a provision for radiological emergency including those with radioiodine and sort out people with high contamination levels that would need to be followed more closely for early detection of signs indicating health effects from radiation exposure. Also the measurement guide such as calibration method for emergencies and error evaluation by counting geometry can be utilized as a preparedness of emergency response plans.

REFERENCES

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