A study on annual variation of the calibration factor of a portable survey meter

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1. Introduction

In the actual field where radioactive isotopes are used, the radiation dose is monitored using a portable radiation meter for radiation protection.
Since the response (calibration factor) of a portable radiation meter is different depending on the radiation level, it must be calibrated appropriately for the radiation level in order to be applied to the field. Therefore, the calibration factor of the measuring instrument according to the radiation level was investigated. Based on the 20 years of experience in the calibration of radiation measuring instruments, this study investigated the annual variation of calibration factors that calibrated about 58,000 or more survey meters for 10 to 20 years.

2. Methods and Results

1. Calibration method

The survey meter was maintained at a certain distance from the reference gamma ray irradiation device, and the radiation dose required for calibration was irradiated to the survey meter and compared with the indicated value on the survey meter.
A gamma ray source was selected according to the radiation dose range, and the response was measured by irradiating it to a survey meter. At this time, the direction of the survey meter detector was adjusted to face the incident source, and the central point was on the central axis of the beam.

2. Measure

After the indicator value of the survey meter is stable, read the indicator value about 10 times every 10 seconds and determine the average as the measured value. Measurement uncertainty is evaluated as an uncertainty factor having a t distribution by taking the standard deviation of the measured value. In the case of an ionizing chamber in which the detector uses free air as an ionizing medium, it is necessary to correct the air density according to changes in temperature and atmospheric pressure.

3. Calculation of Calibration factor

(1) Ambient dose equivalent (rate)
The ambient dose equivalent (ratio) at any distance from the reference standard irradiation device is obtained by the following formula.

$$\dot{H}^*(10) = \dot{K} \cdot h^*(10)$$

where $\dot{H}^*(10)$: ambient dose equivalent (rate) (Sv/h), $\dot{K}$: Air kerma rate (Gy/h), $h^*(10)$: Ambient dose equivalent (rate) conversion factor (Sv/Gy) for air kerma-ICRU sphere depth of 10 mm. At this time, the air kerma-ambient dose equivalent (rate) conversion factor applies the value suggested in KS A ISO 4037-3.

(2) Mathematical model of calibration factor
The calibration factor of the device to be calibrated applied when calibrating the measuring device according to the standard ambient dose equivalent (rate) is calculated according to the following formula.

$$N_r = \frac{\dot{K} \cdot h^*(10)}{M \cdot k_{tp}} \cdot k_d \cdot k_r$$

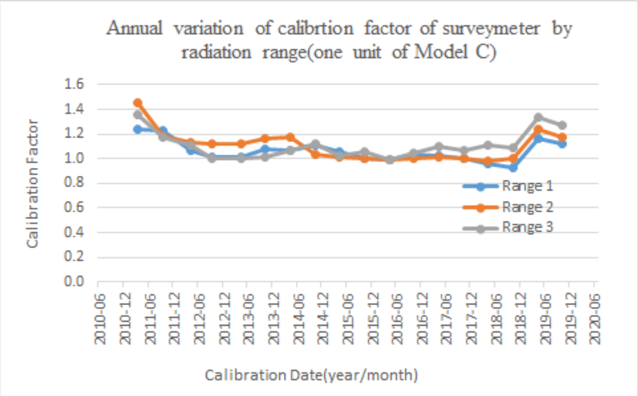
where N_r: calibration factor of the device to be calibrated, $\dot{K}$: Reference air kerma rate (Gy/h), $h^*(10)$: Air kerma-ambient dose equivalent(rate) conversion factor (Sv/Gy), M: Indicated value of the device to be calibrated(Sv/h), k_{tp} : Environmental correction factor (if necessary), k_d : Position reproducibility correction factor of the device to be calibrated, k_r: Resolution correction factor of the device to be calibrated.

4. Results

As a result of measuring the calibration factors of portable survey meters for more than 10 to 20 years, the average calibration factors for the models A and B devices showed an average value (0.993 ± 0.022, 1.013 ± 0.074) and (1.026 ± 0.009, 1.029 ± 0.034) according to the dose rates of 100 uSv/h and 500 uSv/h. And the model C device showed (0.929 ± 0.088 0.976 ± 0.138 1.1023 ± 0.17) according to the dose rates of 100 uSv/h, 500 uSv/h, and 5 mSv/h(See Table and Figure).
Models A(about 1100 units) and B(about 1200 units) are digital survey meters, and calibration factors are maintained very stably. On the other hand, Model C(about 2300 units) is an analog type survey meter, and the value of the correction factor was up to 1.45 depending on the dose rate, but the average correction factor was 1.1023.

Table. Calibration factor according to detector type and radiation level

Detector Type	Dose rate		
	100 uSv/h	500 uSv/h	5 mSv/h
Model A	0.993±0.022	1.013±0.074	
Model B	1.026±0.009	1.029±0.034	
Model C	0.929±0.088	0.976±0.138	1.102±0.170



3. Conclusions

The average value of the calibration factor calculated by using a portable survey meter as a reference gamma irradiator for 10 to 20 years of monitoring showed an annual variation of around 10%. From this, it can be seen that the portable survey meter we are using is suitable as a radiation protection device. However, caution is required when using an analog type survey meter purchased more than 10 years ago.

REFERENCES

[1] ISO 4037-3, X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy — Part 3: Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence, 1999.
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