Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 29-30, 2014

The measurement uncertainty estimation of the portable radiation monitor

Ha-Seok Chai*, Jae-duck Park, Hoon Son, Sang-hoon Seo
Iljin Radiation Engineering Co. Ltd., 19-13, Seogu-dong, Hwaseong-si, Gyeonggi-do, Korea
**Corresponding author: hschaiu@naver.com*

1. Introduction

The calibration and correction of the portable radiation monitor to measure air dose rate by gamma rays is to find out the relation between the value displayed on the measuring instrument and the dose rate by the reference radiation field generated from a reference irradiation equipment.

For calibration, the portable radiation monitor, survey meter, was set on the position to calibrate. After waiting sufficiently until the displayed value was stabilized, the calibration of survey meter was fulfilled.

2. Methods and Results

The detector in the survey meter is located, being orthogonal to incident direction of the beam. And the measuring equipment's left, right, upper, and lower direction is adjusted so that the survey meter detector's central point can be on the beam's central axis, by using the laser controller and the manipulator of the measuring equipment.

The plate or table of calibration is moved to the base point. And it is checked if the measuring point reproducibility equipment(laser or goniometer) central point's movement line is consistent with the base line of the calibration table's upper part. And the measuring equipment's front and rear direction is adjusted so that the survey meter detector's central point can be on the base face including the base point, by using the measuring point reproducibility equipment and the manipulator of the measuring equipment.

And, by using the correction data of the gamma ray irradiator, where the measured dose is formed, is calculated. And the measuring equipment is moved to the corresponding location by using the manipulator. And the beam size controller is selected so that the beam size at measuring point can be 1.5 times larger than the detector size.

3. Applied contents

3.1 Calculation of the calibration factor

In order to calculate the calibrated value, the air-kerma rate to equivalent in case of gamma ray source, Cs-137, the conversion factor is 1.21 Sv/Gy is applied. The conversion factor is calculated according to the following equations. The correction factor is like table 1.

Table 1. Correction factor

Reference dose (mSv/h)	Measured value (mSv/h)	Correction factor
30	28	1.071
50	47	1.064
80	75	1.067
Average correction factor		1.067
Average standard deviation		0.002
Relative standard uncertainty		0.19 %

3.2 Evaluation of uncertainty according to factors

○ Standard uncertainty of the reference absorbed dose(rate) :

If the expansion uncertainty given on the result of gamma ray irradiator is 2.4% by applying the coverage factor k = 2, the relative standard uncertainty is $u(\dot{D}) = 2.4/2 = 1.2\%$ and in this case, the degree of freedom is ∞.

○ Statistical standard uncertainty of average calibration factor :

Standard deviation that the calibration factor's average value gained from the calibration result is applied after being converted to relative standard uncertainty.

○Standard uncertainty of swaying displayed :

The standard uncertainty according to the displaced value's sway is calculated by the following equation.

$$\text{Standard Uncertainty} = \frac{\frac{(\text{Max - Min})}{2}}{\sqrt{6}}$$

$$\text{Relative standard uncertainty} = \frac{\text{standard uncertainty}}{\text{average value}} \times 100\ \%$$

In this case, the degree of freedom is ∞.

○ Resolution's standard uncertainty :

The corrected instrument's scale is generally divided into 25 equal parts. Therefore the standard uncertainty is evaluated, assuming that the half range is rectangular form distribution.

$$u(k_r) = 100 \times \frac{1}{25 \times 2} \times \frac{1}{\sqrt{3}} = 1.15\%$$

○Beam homogeneity's standard uncertainty ：

It is evaluated, assuming that half of 5%(± 2.5 %)the maximum spreading at effective beam size is rectangular form distribution.

$$u(k_{fd}) = 2.5 \times \frac{1}{\sqrt{3}} = 1.44\%$$

○Ddose conversion factor's uncertainty

The relative standard uncertainty is applied as 2% according to the ISO suggestion.

○ Location reproducibility standard uncertainty

In case that resolution of the scale for measuring the distance(e.g. magnet scale) is 1 mm, the relative standard uncertainty to 1000 mm is evaluated, being assumed the rectangular form distribution. And the relative standard uncertainty is evaluated to be twice more than resolution's, as distance affects dose value according to $1/r^{2.}$

$$u(k_d) = 2 \times (k_r) = 2 \times (\frac{1}{1000} \times \frac{1}{\sqrt{3}} \times 100) = 0.12\%$$

According to the above, each factor's uncertainty is summarized like table 2.

4. Conclusions

The calibrated instrument's calibration factor is decided naturally by the once irradiation. Therefore, the displayed value's uncertainty follows the correction factor's statistical standard uncertainty. And, after uncertainty according to factors is evaluated, the relative synthesized standard uncertainty, which is synthesized by multiplying the relative standard uncertainty by the sensitivity coefficient, is calculated as 3 %, 3.2 % each.

Measuring uncertainty, which is expressed as expansion uncertainty, was 3 ×2 = 6 %, 3 × 3.2 = 6.4 % each, double-digits of effective figure being applied at 95% confidence level.

5. References

[1] KASTO X-ray and gamma ray survey meter calibration manual
[2] KRISS-99-070-SP measuring uncertainty expression guide

Table 2. Correction factor

	Amount	Estimated value	Standard uncertainty (%)	Probability distribution	Sensitivity coefficient	Contributed amount (%)	Degree of freedom
A	$\dot{K}$	0.35 ~ 64 mGy/h	0.85	N	1.0	0.85	∞
		6 ~ 125 μGy/h	1.40	N	1.0	1.40	∞
B	h	1.2	2.00	N	1.0	2.00	∞
C	M	0.955 ~ 0.988	1.07	t	1.0	1.07	2
D	k_{fr}	1.0	1.31	t	1.0	1.31	∞
E	k_{fd}	1.0	1.73	R	1.0	1.73	∞
F	k_d	1.0	0.29	R	1.0	0.29	∞
G	k_{tp}	1.013 ~ 1.014	0.02	N	1.0	0.02	∞
H	$\dot{K}_D$	0.976	2.99 %				
			3.19 %				
	Expansion uncertainty		6.0 %				
			6.4 %				