Establishment of Low Dose Rate Calibration Methods for Environmental Monitoring

National Institute of Advanced Industrial Science and Technology

Tadahiro KUROSAWA

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Introduction

- After the nuclear accident on 11 March 2011 in Japan, measuremets of dose rates at various fields are demanded for decontamination and monitoring.
- Many types of portable area monitors are used to measure environmental dose rates, and calibration of less than 1.0 μSv/h is important for quality control.
- Most of the environmental radiation dosimetry monitoring equipment is strongly fixed on site. Due to the large and heavy devices of these instruments, it is difficult to remove these for calibration.

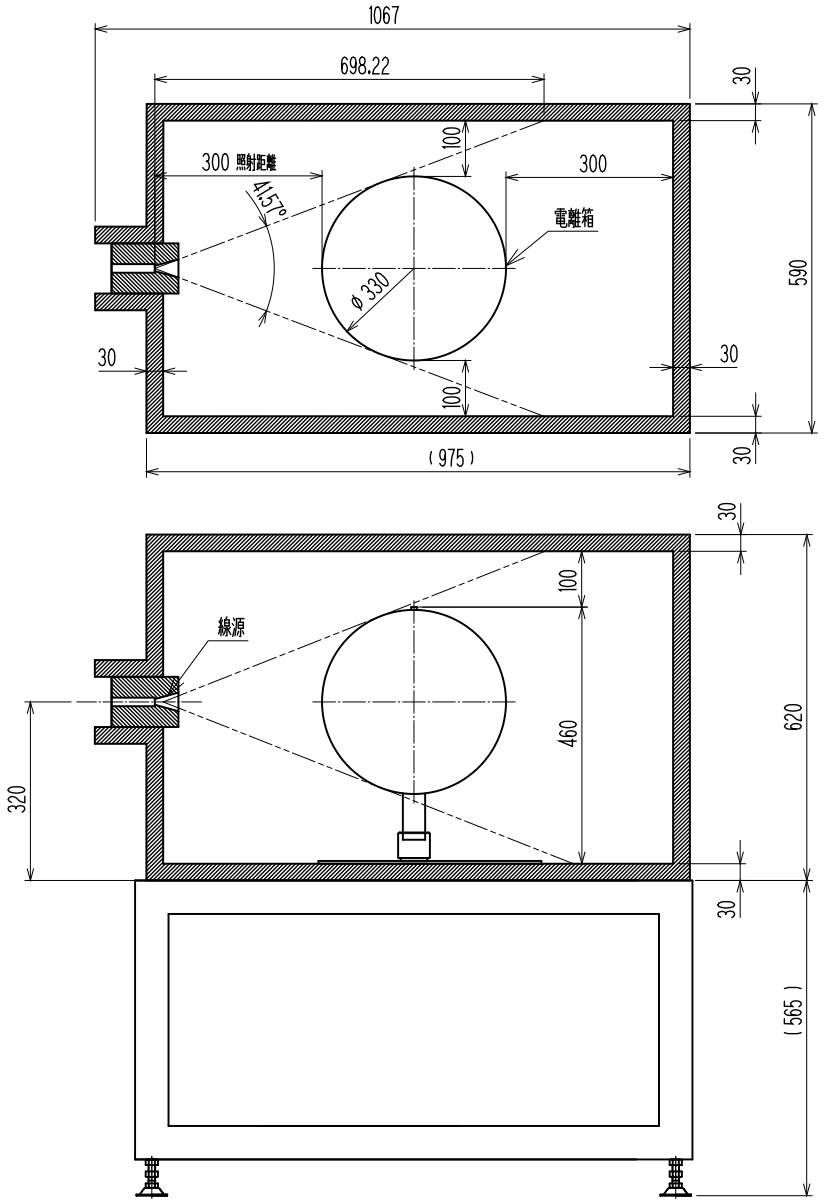
1. The compact low dose-rate irradiation system is developed for calibration of portable area monitors.

2. The on-site calibration method are developed for fixed environmental monitors.

Calibration system for portable area monitors

Low dose irradiation system

- Covered with 30 mm lead
- 2 mm stainless steel and 1 mm Al plates are mounted for shielding the characteristic X-rays from lead.
- The distance from the source to the detector is about 66 cm.



Overview of the Compact Gamma-ray Irradiation System

The evaluation of shielding performance

- Shield layers consist of 2mm lead and 1mm aluminum and the total thickness of shielding materials can be adjusted by the number of the shield layers attached.
- An NaI(Tl) survey meter (TCS-172) and a CdZnTe spectrometer are used for the dose-rate measurements.

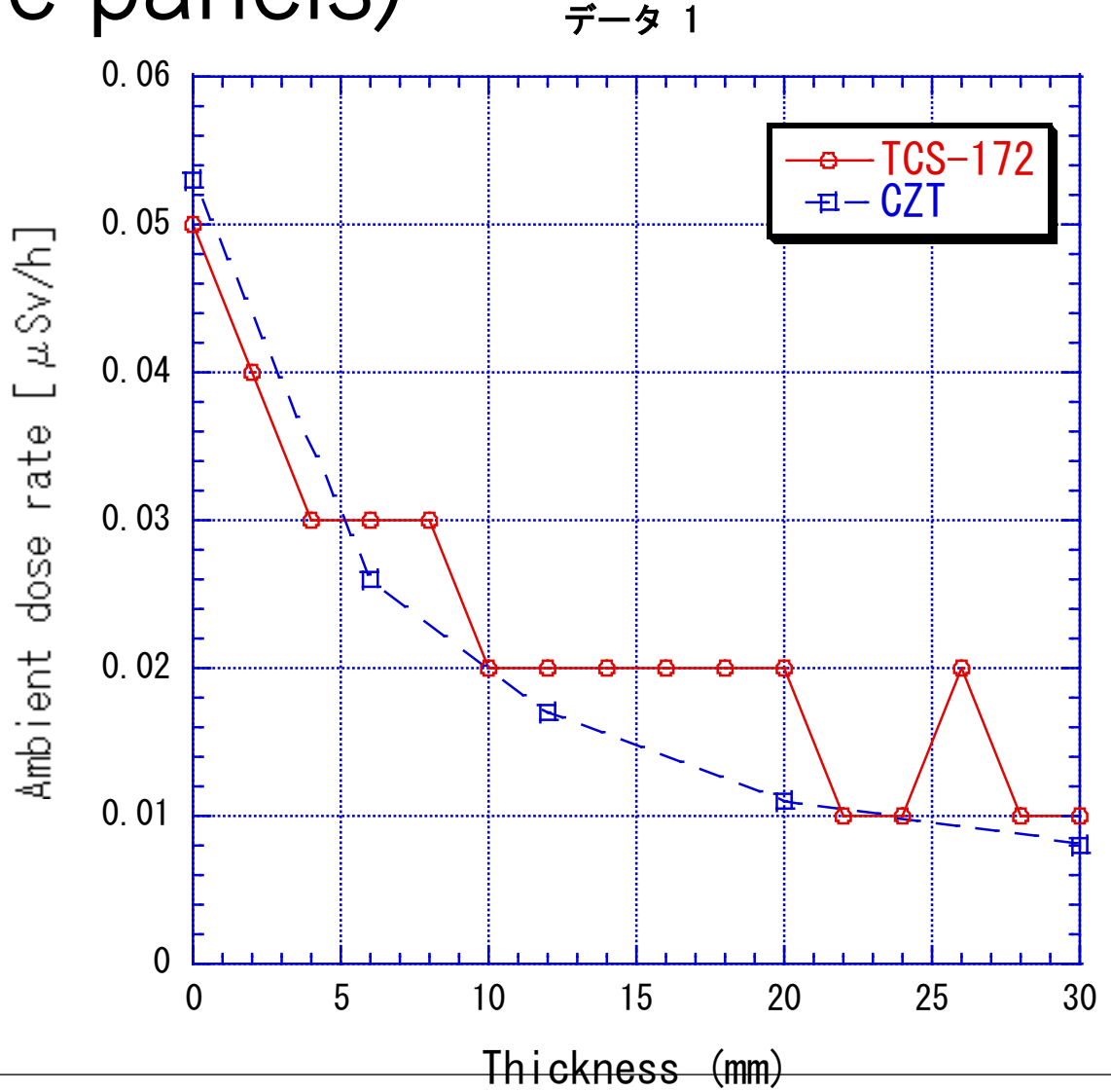
Results for shielding performance (Floor panels)

- BG for without any shielding・・・0.08 μSv/h
- Shielding only for the bottom・・・0.05 μSv/h

0.03 μSv/h is reduced by the bottom shielding

Results for shielding performance (Ceiling and Side panels)

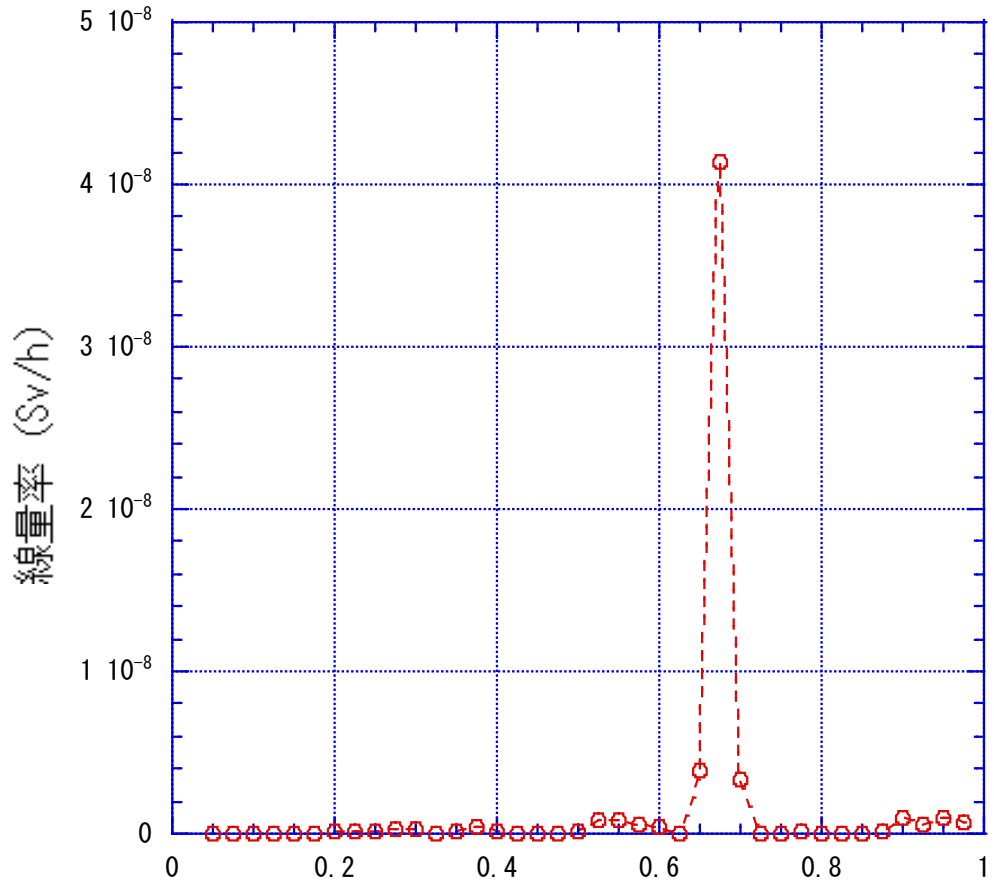
- Dose rates by changing the thickness of the side and top shielding
- This system can reduce a BG dose rate down to around 0.01 μSv/h.



Scattering radiation in the irradiation system

- The photon energy spectra of Cs-137were measured in this irradiation system with the CdZnTe detector to evaluate the contribution of scattered photon.
- The measured data were unfolded to obtain the photon energy spectra

- Both of the dose rates of scattered photons are less than 10 % of those of the direct gamma-rays from Cs-137



Comparison between this system and the standard irradiation room

- The dose rates in the low dose-rate irradiation system were compared with the dose rate in the standard irradiation room at AIST

Detector	Ratio of dose rate (18.5G/3.7M)	Normalized to the value of 1500 cm^3 chamber
15L cavity chamber	25.57	1.0
CZT detector	25.75	1.007
NaI(Tl) survey meter	26.06	1.019

- The discrepancy of the ratios for the three detectors is less than 2 % and it's within the uncertainty.

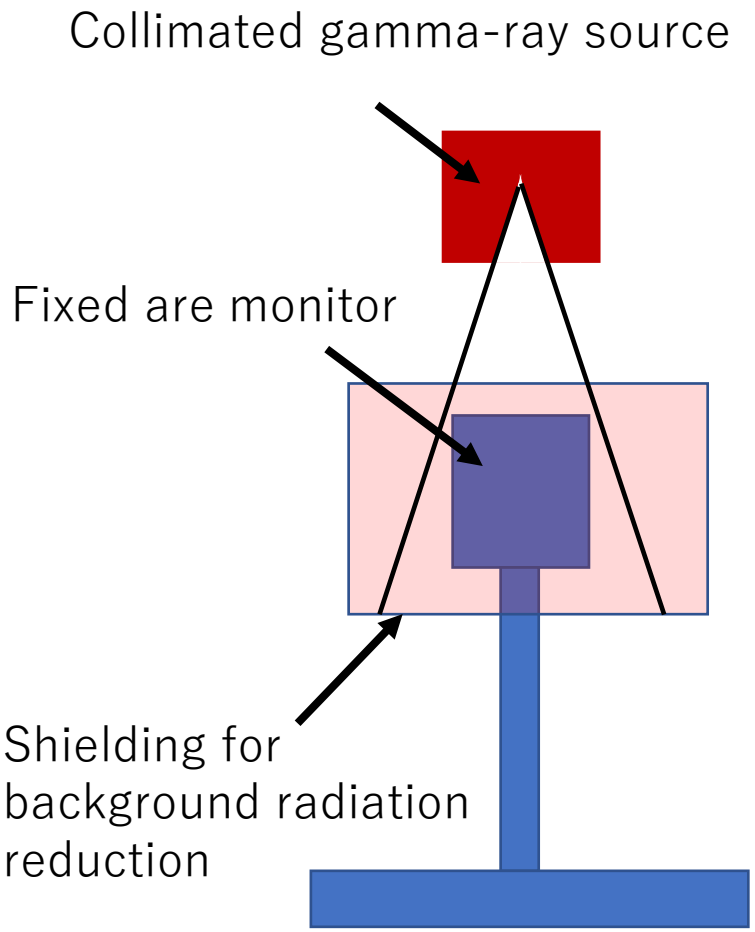
Uncertainty budget for low dose calibration system

	Relative uncertainty (%)
Calibration coefficent for 15000cm^3 chamber	1.1
Current measurement	1.2
Temperature	0.1
Pressure	0.1
Humidity	0.02
Position of chamber	0.18
Position of source	0.18
Non-uniformity	1.01
Conversion coefficient for H*(10)	0.63
Combined standard uncertainty for air-kerma	1.92
Combined standard uncertainty for H*(10)	2.02

On-site calibration method for fixed area monitors

Irradiation system for on-site calibration

- The characteristics of the irradiation system
  - Collimated irradiation independent of installation environment and peripheral equipment (Easier uncertainty evaluation)
  - Reduction of calibration time (easy installation)
  - Reduction of background radiation using shielding for are monitor (possible to calibrate at high background environment)



Calibration at Fukushima

- The calibration result of the movable area monitor at high background and low background places

Calibration at Fukushima using on-site calibration system

Calibration place	BG without shielding (μGy/h)	BG with shielding (μGy/h)	Shielding effect (%)	Indication for calibration (μGy/h)	Calibration constant
Fukushima1	2.81	1.50	53	5.43	1.06
Fukushima2	3.74	1.72	46	8.65	1.07

Calibration at low background place using the reference cavity chamber

Calibration distance (m)	Dose rate (μGy/h)	Calibration constant	Uncertainty ($k = 2$) (%)
1.5	0.83	1.06	7.5

・The shielding effect is about 50 %.
・The results of this method were found to be equivalent to those of the conventional method.

- Uncertainty for the calibration using this system

Uncertainty components	Relative standard uncertainty (%)
Determination of dose rate for irradiation system	1.4
Interpolation of dose rate	1.6
Position	1.9
Non-uniformity	0.6
Dose rate measurements of area monitor	0.4
Combined relative standard uncertainty	2.9
Expand relative uncertainty ($k = 2$)	5.9

・The advantage of this system for the estimation of uncertainty
○No need to evaluate the uncertainty of the effect of scattering radiation
(2 to 10 % for non-collimated irradiation)

Thank you very much for your attention!