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Uniformity measurement of wide area reference sources for beta emitters

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HIGHLIGHTS

- A system consisting of a proportional counter and a motorized stage was installed.
- The neighbor effect from surroundings on the measurement was carefully determined.
- Uniformity measurement could be conducted with a neighbor effect of 15% or less.

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ABSTRACT

When conducting uniformity measurements of a wide area reference source with a detector having a window of a size similar to that of a gridded individual portion area on the source, it is important to carefully consider neighbor effects on measuring emission rates of the individual target portion resulting from the gap between the source and detector window. Optimization of the uniformity measurement conditions was studied for beta-emitting wide area reference sources in this study. A measurement system consisting of a PR-gas (Ar: 90%+CH_4: 10%) flow type windowed proportional counter and a motorized XY stage was installed. This system is adapted to the uniformity measurement of two different types of ^{36}Cl sources made by different manufacturers. Uniformity measurement of a 100 mm × 100 mm source divided into 16 portions of 6.25 cm^2 (25 mm squared) each could be conducted using our system under the present conditions with a neighbor effect of around 15% or less. The measurement results by use of this system were also compared with those using the imaging plate technique.

1. Introduction

Properties of wide area reference sources involving the criteria of uniformity are discussed in ISO 8769 (ISO, 2010). This international standard requires that uniformity and its uncertainty be stated, expressed in terms of standard deviation of the surface emission rates from each individual portion of the whole source. The area of each portion is requested to be equal or less than 5 cm^2 with a contribution from the surrounding portions less than 5%. (Nähle and Kossert, 2012) successfully measured uniformity of photon-emitting wide area reference sources. However they also pointed out that it was difficult to fulfill the ISO requirements for the maximum allowed size of a sub area and contribution from surrounding portions. In response to their study ISO decided to change the requirement from “5 cm^2 or less” of each portion area to “10 cm^2 or less” (ISO, 2015). When measuring individual portions, the neighbor effects should be carefully considered for beta-emitters as well. In this study, optimization of uniformity measurement conditions was studied for beta-emitting wide area reference sources taking into consideration the results obtained by Nähle et al. and potential changes in the next revision of ISO 8769.

2. Experimental arrangement

The schematic design of the uniformity measurement system used in the present work and installed at the Japan Radioisotope Association (JRIA) is shown in Fig.1. The detector system consists of a PR-gas flow type windowed proportional counter and a motorized XY stage below the counter that allows computer controlled positioning of sources. The counter has a changeable rectangular shaped window with an aluminized Mylar foil of 0.29 mg/cm^2 thickness. While the source-to-detector distance should be minimized to reduce the contribution from surrounding portions, the source face and detector window were separated by a 2 mm gap to avoid damaging the source.

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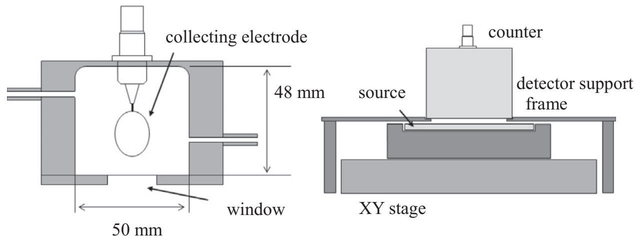

Fig. 1. Schematic view of the uniformity measurement system installed in JRIA. The sectional view shown on the left side is the detector part of the system.

The signal from the detector was processed simply with a preamplifier, linear amplifier and single channel analyzer. The logic pulses from the linear amplifier were fed to a counter/timer module. The counter and XY stage can be controlled by common software to synchronize the actions of the counter and XY stage. Measured data including the date of measurement, duration of measurement, counts and position of the XY stage are obtainable in a CSV format.

As for the sources used in the present experiments, we employed ^{36}Cl sources, since ^{36}Cl was recommended as a typical nuclide for testing in several IEC standards (e.g. IEC 60325 (IEC, 2002)) for surface contamination monitors. An anodized source and and ink-jet source manufactured by Eckert and Ziegler Nuclitec and JRIA were used, respectively. The ink-jet source was made by printing on a 0.1 mm thick polyethylene film, which was fixed afterwards on an aluminum backing of 3 mm thickness. The film was covered with a 0.9 mg/cm^2 aluminized Mylar foil. Further details on the construction and characteristics of the ink-jet source are given elsewhere (Yamada et al., 2012). Both types of source had the same active area of 100 mm × 100 mm. The details of the wide area sources used in this experiment are summarized in Table 1.

3. Optimization of window size of the detector

According to ISO 8769 the extended source shall be considered as comprising a number of portions of equal area to specify the uniformity of a source with respect to the surface emission rate per unit area. In the present study the proportional counter aperture was set to correspond to the size of a gridded individual portion area on the source. The masking plate integrated in the detector needs an appropriately sized aperture and should provide sufficient shielding of the detector. However, a contribution from areas outside the aperture area may still remain and the determination of such a contribution is not straightforward since it still may significantly depend on the source-to-detector geometry even for β-emitters. To clarify this, a Monte-Carlo simulation technique using EGS5 (Hirayama et al., 2005) was adopted for the evaluation of the neighbor effects. In the present simulation the source model shown in Fig. 2 was used. In order to simulate the real source employed in the present measurements, backing materials (120 mm × 120 mm aluminum of 3 mm thickness) and aluminized Mylar foil window were also included in the source model geometry used in the simulation. In this model the source active area was divided into three areas. Area I was set so as to have the same square sized area as the detector window that

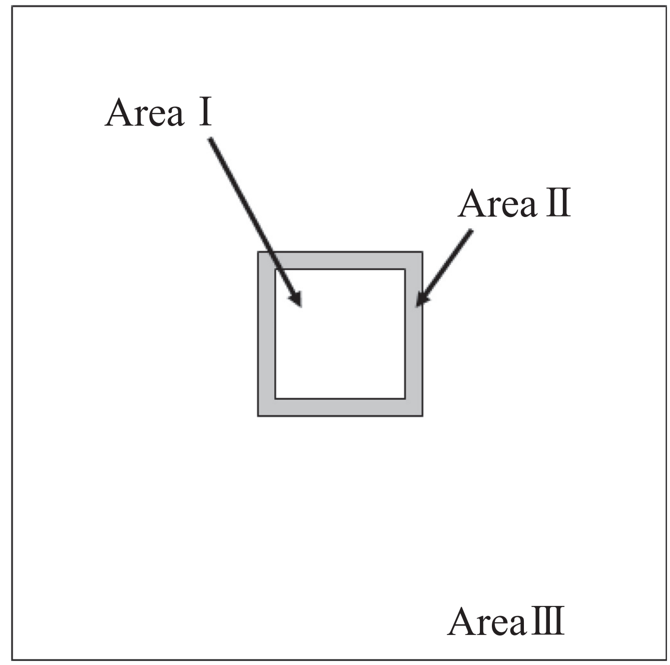

Fig. 2. Source model used in the present simulation. The areas I, II and III are located inside borderlines 1, 2 and 3 respectively.

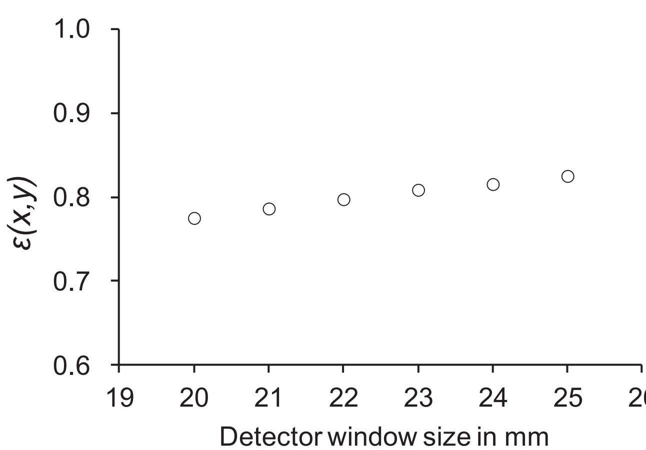

Fig. 3. Counting efficiency for various sizes of window with the source having the same active area size as the detector window. Notations (x, y) indicate (x mm squared of active area y mm squared of the detector window), respectively.

Table 1
Details of wide area sources used in this experiment.

Type	Anodized	Ink-jet
Dimensions of source	100 mm × 100 mm	100 mm × 100 mm
Depth of active layer	6 μm	5 μm
Backing	3 mm aluminum	3 mm aluminum
Window	–	0.9 mg/cm^2 aluminized Mylar
Manufacture	Eckert and Ziegler Nuclitec	JRIA