# Calibration for wide-area Beta sources with windowless multi-wire proportional counter(MWPC)

YoungJu, Lee*, B.D.Lee., Y.B. Choi
*Radiation R&D office., Nuclear Engineering & Technology Institute., KHNP.,*
*P.O Box 25-1,Yuseong, Daejeon, Republic of Korea.*
**Corresponding author: ramsess55@khnp.co.kr*

## 1. Introduction

Extended area sources are mainly used as reference sources for calibrating surface contamination monitors in terms of the surface emission rate [1]. Therefore, it is very important in the field of radiation protection to determine the surface emission rates of the reference sources precisely. A windowless gas flow MWPC system manufactured by the Korea Institute of Standards and Science (KRISS) was adopted as a calibrator. Considering wide range of area sources with various dimensions and radio-nuclides, MWPC was designed to have a large sensitive volume.

This letter describes the establishment of the "working high voltage" and the "emission rate" of particles in 2π sr. These factors are expressed as particles/s in 2πsr with various wide- area Beta sources.

## 2. Experimental equipments

### 2.1 MWPC

The gas inlet and outlet used here were installed at the opposite ends of a diagonal line, and a BNC connector was installed in the center of one side of the MWPC body. The inner size of the chamber is 350mm × 250mm×30mm. The body of the detector is of stainless steel, as this material emits a low background, lasts for a long time, and does not rust. The inner surface of the detector was polished to minimize electric noise when establishing the electric fields inside the chamber. An O-ring was used to prevent gas leakage.

There are two planes inside the chamber: an anode plane and a cathode plane. The distance between the two planes is 10 mm, which equals the distance between the counter wall and the anode plane. The anode plane consists of 21 anode wires with a spacing of 10 mm between the wires. On the other hand, the cathode plane consists of 42 wires with a spacing of 5 mm. The MWPC consists of a gas supply system, a pre-amplifier, a shaping amplifier, a single-channel analyzer (SCA), a multi-channel analyzer (MCA), a dead time circuit, a counter/timer, and a high-voltage power supply. The wire material is 0.05 mm stainless steel. The wires are soldered to the supporting frames in such a way that the tension of all the wires is identical. Considering the operating cost, P-10 (90% Ar and 10% $CH_4$) was used as a fill gas.

### 2.2 Extended area sources

In this experiment, five types of Beta emission sources with the same dimensions were used. The active area of the rectangular sources is 100 × 100 $mm^2$, and the radio-nuclides $^{14}C$, $^{99}Tc$, $^{36}Cl$, $^{90}(Sr/Y)$ and $^{137}Cs$ were utilized. The energy of each Beta source varied from 49.44 keV to 556keV. The backing plated is made of aluminum.

### 2.3 Methods

The background was subtracted using a standard technique. From the registered counting rate *m*, the corrected counting rate *M* was obtained with the customary formula:

$$M = \frac{m_s}{1 - m_s \times \tau} - \frac{m_b}{1 - m_b \times \tau} \qquad (1)$$

where $m_s$ and $m_b$ denote extended area sources and the background count rate, respectively. Additionally, τ indicates the means resolution time. The high voltage was calculated using equation (2).

$$V = V_1 + \frac{V_2 - V_1}{3} \qquad (2)$$

$V_1$ and $V_2$ are starting voltage and end voltage of the Beta plateau respectively. Uncertainties were calculated in compliance with the ISO-Guide to the Expression of Uncertainty Measurement, 1995.

## 3. Results

### 3.1 High-voltage plateau curve

The high-voltage plateau curve was used to determine the operational voltage. The chamber was opened, the area source was inserted at the center, and the chamber was then closed. The counter was then flushed with P-10 gas at a high flow rate for at least 5 min. This was necessary to remove the air and moisture that got into the chamber while it was open. Fig. 1 shows the plateau curve as a function of the high voltage. This figure clearly shows a plateau from 1.8 to 2.2 kV. The plateau slopes are calculated at less than 1% per 100 V. The values of the average Beta energy versus the operational voltage of each source are plotted in Fig. 2. The operating voltage shows an increasing trend according to the average Beta energy; however, this incremental of operational voltage did not greatly influence the counting rate.

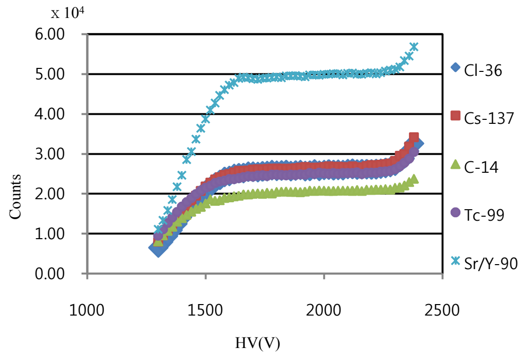


Fig. 1. MWPC High voltage counting curve

At 1,900V, which was selected as the operational voltage, the sensitivity of the system to voltage drifts was minimal.

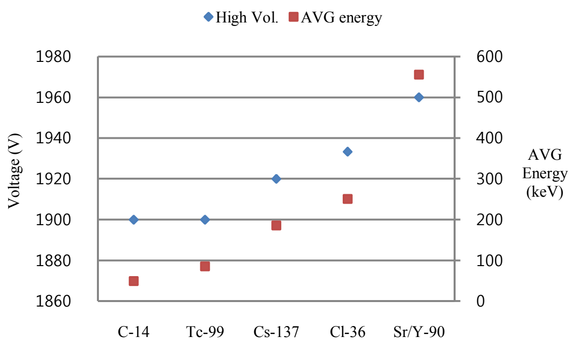


Fig. 2. Beta Energy vs. operating voltage curve

3.2 Sources and background counting rate

Background count rate of the Beta sources were 16.47cps and the MDA value was 0.041Bq. To calculate the final surface emission rate, the background value was subtracted. Table 1 shows the surface emission rate and efficiency.

Table 1 source emission rate & efficiency

| | surface emission rate | *uncertainty | efficiency |
|---|---|---|---|
| C-14 | 391 | 0.45 | 0.9051 |
| Tc-99 | 483 | 0.42 | 0.9955 |
| Cs-137 | 520 | 0.47 | 0.8965 |
| Cl-36 | 503 | 0.32 | 0.9092 |
| Sr/Y-90 | 989 | 0.57 | 0.8972 |

*statistical uncertainty

3.3 Combined uncertainty

The relative combined uncertainty was calculated using the following equation [2]:

$$u_c^2 = u_m^2 + u_\varepsilon^2 + u_w^2 + u_d^2 + u_t^2 + u_r^2 \qquad (3)$$

Here, $u_m$ and $u_\varepsilon$ are the type A (statistic) components, and the others are the type B components. For $u_m$, a maximum value of (0.06~0.12%) was obtained, which is quite acceptable for extended sources. When the value of $u_\varepsilon$ could be obtained from the MWPC certificate, it is 1.05%. Several sources were found to contribute to the systematic uncertainty. In this experiment, four types of components for type B uncertainty were selected. In this case, $u_d$ represented the amount of radioactivity disintegration and $u_t$ and $u_r$ are related to the dimensions of the wide area sources. These components can be ignoring because they are not important when measuring the emission rate of sources using MWPC. The uncertainty ($u_w$) for the threshold cut was determined as only 0.16% of the source count rate (Fig. 3)

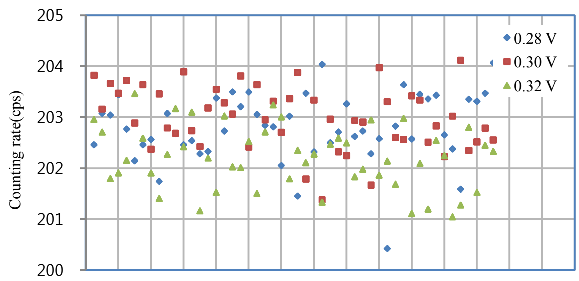


Fig. 3. Counting rate according to the Energy Widow

The combined standard uncertainty in the emission rate measurements calculated according to the law of propagation of uncertainty wass 2.2% at k=2, at a confidence level of nearly 95%.

## 4. Conclusion

An efficiency system for the standardization of extended beta sources was realized. It uses a large area-multi-wire proportional counter without a window and P-10 gas. Extended beta sources of $^{14}C$, $^{99}Tc$, $^{36}Cl$, $^{90}(Sr/Y)$ and $^{137}Cs$ were standardized. Various characteristics of the detector were investigated, and several working parameters based on these studies are given. The graph of the counting rate versus the high voltage provided plateaus of (1,900-1,960) V, with slopes of (0.43-0.64) % for 100V. Beta operating voltages according to their average energy have similar relative values. The obtained relative combined uncertainty, $u_c$, was 2.1%, which is quite acceptable for extended sources.

## REFERENCES

[1] K. B. Lee, J. M. Lee, T. S. Park, Measurement of beta surface emission rate from an extended area $^{36}Cl$ sources using a multi-wire proportional counter, Appl. Rad. Isot., 63, 99-105(2005).

[2] E. L. GRIGORESCU, M. SAHAGIA, A. C. RAZDOLESCU, A. LUCA, C. IVAN, Standardization of large area alpha and beta sources with a windowless multi-wire proportional counter, Romanian Report in Physics, Vol. 60, No. 3, 909-916(2008).