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Determination of Ion Recombination Correction Factor in a Spherical Ionization Chamber for ^{60}Co Gamma-Ray

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Introduction

In the determination of air kerma using an ionization chamber one of the important correction is the ion recombination correction. This phenomenon occurs when the + and - ions formed along the charged particle tracks meet and recombine. There are two processes in the ion recombination. One is the initial recombination process that occurs when ions from the same charged particle track meet to recombine and the other is the volume recombination process that occurs when ions from different tracks encounter each other on their way to the collecting electrode. The purpose of the present paper is to investigate the problem of ion recombination in a spherical ionization chamber and obtain parameters governing the initial and volume recombination to determine the ion recombination correction factor for ^{60}Co gamma-rays. The spherical ionization chamber used in this study was a 1 cm^3 graphite wall chamber (FWT-182).

Method and Theory

The fundamental equation for estimating the ion recombination near the saturation current is given by [2]

$$\frac{I_S}{I_V} = 1 + \frac{A}{V} + \frac{m^2 g}{V^2} I_S \qquad (1)$$

where I_S is the saturation current and I_V is the ionization current measured at applied voltage V. A is a parameter related to the initial recombination process, m^2 is the parameter governing the volume recombination and g is the geometric factor given by Boag [1]. For the determination of the parameters, the method was proposed by De Almeida and Niatel [2]. Substituting V/n into V in the equation (1), where n is not necessarily an integer, the equation becomes [2]

$$\frac{I_V}{I_{V/n}} = 1 + (n-1)\frac{A}{V} + (n^2-1)\frac{B}{V^2} I_V \qquad (2)$$

where $B = m^2 g$. In the equation (2), the higher order terms of I_V were neglected because A and B are very small compared with the applied voltage. The geometrical factor g is the order of unity. The parameters are obtained by the linear plot of the ratio $\frac{I_V}{I_{V/n}}$ versus I_V at the given applied voltage V. The parameters A is derived by the extrapolation of the linear curve to $I_V = 0$ and B is from the slope of the curve.

For the measurement the chamber was placed in the reference plane at 1 m from the ^{60}Co

source. Measurement of the ionization current were made for 5 selected voltages from V/n = 250 V to 40 V. For the change of the ionization current, the Al and Pb filters were attached to the collimator of the irradiator. Several combinations of the filters were chosen to make the 8 measurements of the ionization current at each applied voltage. Ratio $\frac{I_V}{I_{V/n}}$ were measured in the ionization chamber with voltages V/n as a function of I_V for several values of n.

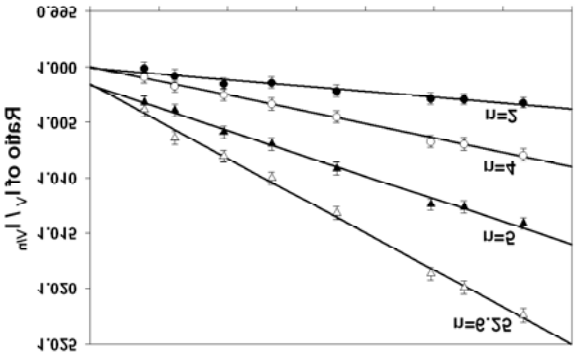

Fig. 1. Ratio of $I_V/I_{V/n}$ as a function of I_V. The slop and the intercept of the curve correspond to $(n^2-1)\frac{B}{V^2}$ and $1+(n-1)\frac{A}{V}$, respectively in the eq. (2).

The ionization currents for both polarities of the applied voltage were measured to estimate the polarity effect. For the current measurement, the voltage was set at ±250 V and the mean value was taken as the effective value. In our study, the negative polarity was applied for the current measurement and thus polarity correction was done by the ratio of the ionization currents at -250 V to the mean value.

Result and Discussion

From the 4 sets of $\frac{I_V}{I_{V/n}}$ versus I_V measurements, the initial recombination parameter A and the volume recombination parameter B were derived. The average value of the A was 0.0498 [V] and B is 0.1368 $\left[\frac{pA}{V^2}\right]$. From the two parameters, the ion recombination correction factor for the 1 cm^3 spherical ionization chamber was given as 1.0009. The uncertainty obtaining each A and B was 0.044 %. The correction factor of the polarity effect was 0.9999.

Conclusion

The problem of ion recombination in a spherical ionization chamber for ^{60}Co gamma-ray was investigated experimentally. The initial and volume recombination parameters A and B have been obtained from the measurement of the ratio of $I_V/I_{V/n}$ as a function of I_V at two given applied voltages V and V/n, where n is a positive number, as a function of I_V. From these parameters, the ion recombination correction factor was determined.

Reference

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