Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Nuclear Instruments and Methods in Physics Research A 580 (2007) 242–245
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

Output current variation and polarity effect by electric field and ion-pair non-uniformity inside thimble-type ionization chamber

Jaecheon Kim[a], Yong Kyun Kim[a], Soon Young Kim[b], Jong Kyung Kim[a,*]

[a]*Department of Nuclear Engineering, Hanyang University, 17 Haendang-dong, Seongdong-gu, Seoul 133-791, Korea*
[b]*Innovative Technology Center for Radiation Safety, Hanyang University, 133-791, Korea*

Available online 16 May 2007

Abstract

A new analytic approach considering both electric field and ion-pair non-uniformity has been proposed to accurately analyze the design characteristics of an ionization chamber and to interpret measurements. It is commonly assumed that ion-pairs are generated uniformly in the air volume, but such an assumption ignores various source and geometry conditions. The new approach was applied to angular dependence analysis and to polarity effect assessment in an ionization chamber. For the angular dependence analysis, whole, uniform, and non-uniform output currents were calculated as a function of the irradiation angle for an ^{241}Am gamma-ray source. The non-uniform output current proposed in this paper was found to be closer to the measured one. This is because the non-uniform output current takes into account the ion-pair distribution in the air volume as well as the active volume determined by the electric field. For the polarity effect assessment, the amount of field distortion due to potential difference and actual current difference was calculated. Previous methods cannot appropriately estimate the variation of polarity effect because they ignore the influence of the ion-pair distribution. The polarity effect assessment using the non-uniform output current can be more useful for obtaining the practical current difference, because this assessment considers both the variation of active volume and the ion-pair non-uniformity according to source conditions such as the irradiation angle and the distance. It is important to precisely calculate not only the active volume, but also the variation in the ion-pair distribution.
© 2007 Elsevier B.V. All rights reserved.

PACS: 29.40.−n; 29.40.Cs

Keywords: Output current; Ion-pair non-uniformity; Ionization chamber; Angular dependence; Polarity effect

1. Introduction

Accurate simulation of an ionization chamber's output current aids in the analysis of design characteristics and measurements. The output current of an ionization chamber is directly related to the size of the active volume and the ion-pair distribution in the air volume.

The ion-pair distribution depends mainly on the irradiation source conditions, while the active volume depends on the ionization chamber design. Former models have ignored various source and geometry conditions. Such assumptions need to be examined to accurately model an ionization chamber.

This paper proposes a new analytic approach that considers both the electric field and the ion-pair non-uniformity. An angular dependence analysis and a polarity effect assessment were carried out for validation.

2. Methods

When an incident radiation interacts with an ionization chamber, the ion-pairs are not created uniformly within its air volume, because gamma-ray energy tends to be more actively deposited in the near wall surface than in the center. Ions formed in the gas volume can be drawn either to the guard ring or to the collector. The guard ring is usually inserted between the collector and the high-voltage electrode to intercept the leakage current. The ions collected at the guard ring do not contribute to the output

*Corresponding author. Tel.: +82 2 2220 0464; fax: +82 2 2294 4800.
E-mail address: jkkim1@hanyang.ac.kr (J.K. Kim).

0168-9002/$ - see front matter © 2007 Elsevier B.V. All rights reserved.
doi:10.1016/j.nima.2007.05.092

current of an ionization chamber. Therefore, the guard ring design can considerably influence the total amount of output current. Fig. 1 shows the ion drift lines based on the electric field and the active volume of two ionization

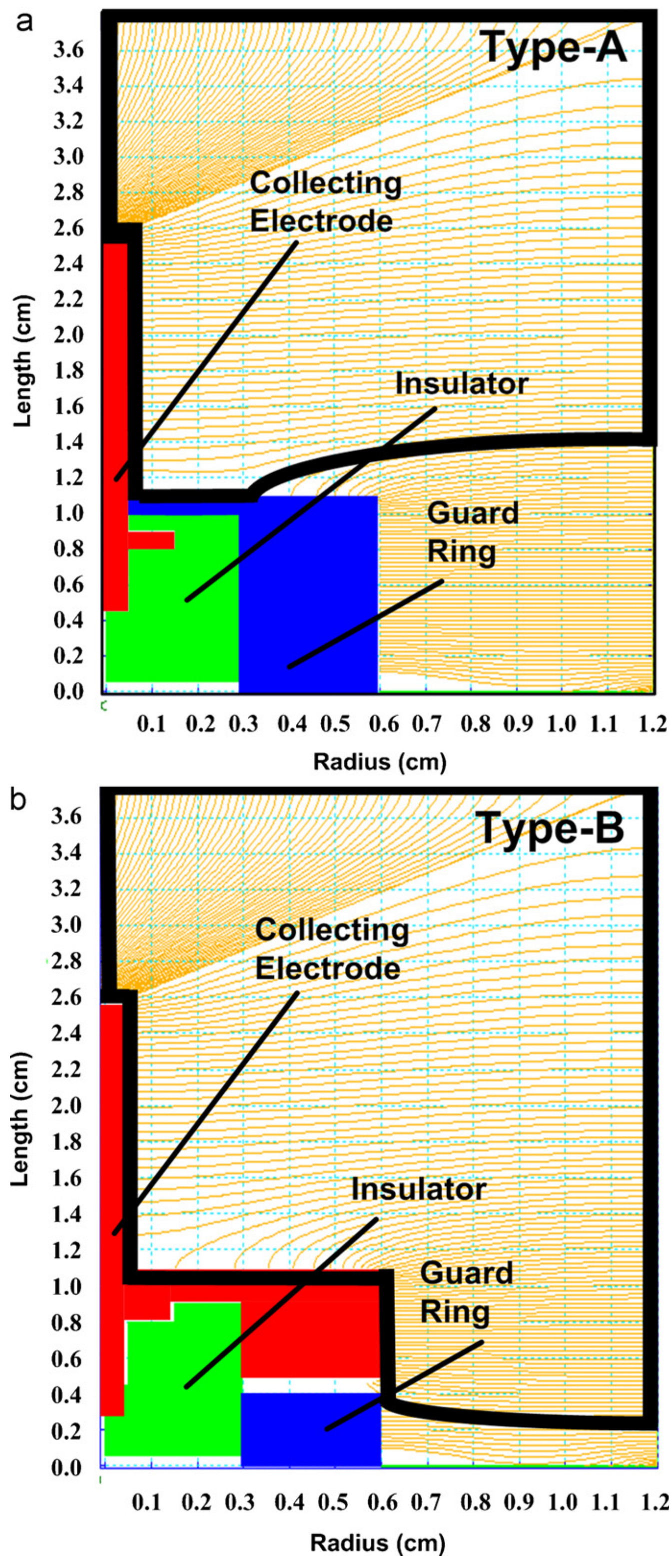

Fig. 1. Active volume of the ionization chambers with Types-A and -B guard ring.

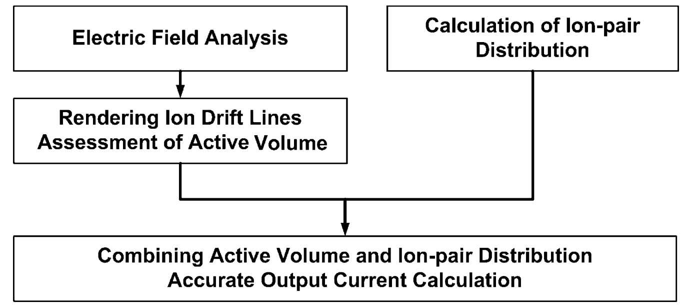

Fig. 2. Calculation procedures for non-uniform output current.

chambers with a different guard ring design, respectively. Based on the ion drift lines drawn to the collector, the size of the active volume was determined. Its area is indicated with a black solid border. Note that the guard ring of Type-B ionization chamber is inserted deeper into the gas volume. MAXWELL® and Garfield programs, long used in gas detector design, were employed to render the electron/ion drift lines in the air volume [1].

Through the assessment of ion drift lines, the active volume can be quantitatively calculated. The Monte Carlo codes MCNP5 and EGSnrc were used to calculate the ion-pair distribution in the gas volume. The gas volume was divided into many small cells and their absorbed doses were calculated. The number of ion-pairs in each cell was calculated by dividing the absorbed dose by the *W*-value for air.

In this study, the output current simulations were classified into three types: whole current, uniform current, and non-uniform current. The whole current assumes that all ion-pairs generated in the air volume reach the collecting electrode. Thus, the entire air volume is assumed to be active. Uniform current considers the electric field in order to determine active volume, but assumes uniform ion generation in the air volume. Non-uniform current, as presented in this paper, determines the active volume from the electric field, and the ion-pair distribution from various source conditions. The calculation procedures for non-uniform output current are shown in Fig. 2.

3. Angular dependence analysis

Both calculations and measurements were performed to investigate the output current dependence on irradiation angle from an ^{241}Am source, as shown in Fig. 3 [2].

The current fraction, which is the current ratio to the whole current, was employed to examine the influence of the ion-pair distribution. The current fractions for uniform and non-uniform currents were defined as $F_{\rm uni} = Q_{\rm uni}/Q_{\rm whole}$ and $F_{\rm non} = Q_{\rm non}/Q_{\rm whole}$, respectively. Fig. 4 shows the variation of current fraction in the ionization chamber as a function of the irradiation angle.

The results demonstrate that the current fraction calculated for non-uniform current is dependent on the irradiation angle, while uniform current is constant.

Download English Version:

https://daneshyari.com/en/article/1830545

Download Persian Version:

https://daneshyari.com/article/1830545

Daneshyari.com