A PARALLEL PLATE IONIZATION CHAMBER FOR ELECTRON DOSIMETRY

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ABSTRACT

A parallel plate ionization chamber for electron dosimetry was developed and tested in relation to the metrological characteristics: short and medium-term stabilities, leakage current and response to electron beams up to 13 MeV. The polarity effect was also investigated. The obtained results show that they are within the international limits recommended for a secondary standard chamber.

INTRODUCTION

The increasing utilization of linear accelerators in radiotherapy treatments has imposed the necessity of use of parallel plate ionization chambers for dosimetry of the electron beams with energies lower then 15 MeV, as recommended by the dosimetry protocols[1,2,3]. In the present work an ionization chamber of this kind was designed and constructed at the Calibration Laboratory of IPEN. Such chambers may be calibrated in future by comparison with cylindrical ion chambers in a phantom irradiated by ^{60}Co gamma rays[4], without the need for an electron fluence correction.

DESIGN AND CONSTRUCTION OF THE IONIZATION CHAMBER

The parallel plate ionization chamber developed in this work has a circular shape, is mainly made of Lucite and presents an active volume of 0.06 cm^3. The entrance window consists of a thin polyetylene foil coated with graphite (0.84 $mg.cm^{-2}$); the collecting electrode is made of a graphite block (3 mm thickness) and a graphite coated slice of Lucite (0.15 mm). The distance between the electrodes is 2 mm; the external diameter and height of the chamber are 54 and 17.5 mm respectively. A schematic diagram of the chamber is shown in Figure 1.

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EXPERIMENTAL MEASUREMENTS

The chamber was connected to a Keithley model 617 electrometer in order to allow measurements with both polarities. The tests were made in electron beams up to 13 MeV, using a phantom made of Lucite slices.

The short-term stability was determined through 10 consecutive measurements using a check source of ^{90}Sr. The percentual standard deviation showed values between 0.14 and 0.34%. For the medium-term stability test 15 series of measurements were performed at different days. The response presented a variation lower than 0.5% in relation to the mean value: Figure 2.

The leakage current was measured several times during 1 h with intervals of 5 min and showed always values lower then 0.4%. The chamber presented an ion collection efficiency higher than 99%, when operated at a collecting potential of 250 V.

The polarity effect of the chamber was investigated in a 10 MeV electron beam, taking measurements for both polarities and varying the Lucite absorber thickness (z) up to the practical electron range (R_p). The polarity effect was lower than 1% at the maximum ionization depth and it increased for greater depths: Figure 3. All standard deviations of these measurements were lower than 0.25%.

According Goswami and Kase[5] the replacement factor for parallel plate ionization chambers in electron beams above 13 MeV is approximately 1 and probably not significant. In the present work the chamber response was compared to that of a calibrated thimble chamber (Capintec-C II model 66080, 0.6 cm^3) in a electron beam of 13 MeV. The obtained calibration factor was 1.04 cGy/s.u. (s.u.: scale unit).

CONCLUSION

The developed parallel plate ionization chamber presented metrological characteristics, as short and medium-term stabilities, leakage current, ion collection efficiency, polarity effect and calibration factor comparable to those of commercial ionization chambers. The obtained values, within the recommended ones for this kind of radiation, demonstrate the usefulness of the chamber for electron dosimetry.

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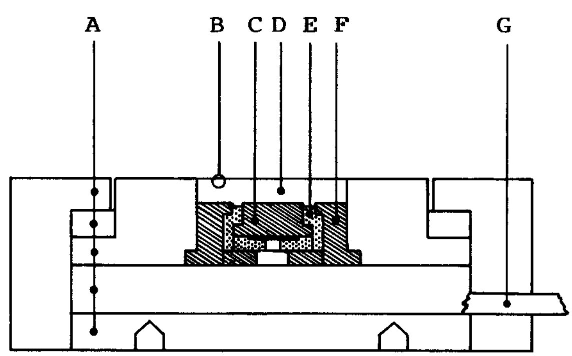

Figure 1: Schematic diagram of the parallel plate ionization chamber for electron dosimetry.
A: Chamber body (Lucite); **B:** Entrance window;
C: Collecting electrode (graphite); **D:** Active volume ($0.06\ cm^3$); **E:** Insulator (Teflon); **F:** Guard-ring (graphite); **G:** Triaxial cable.

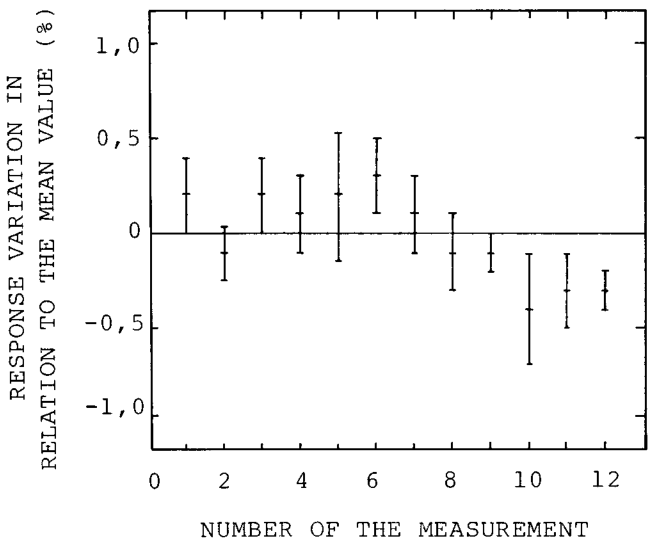

Figure 2: Medium-term stability test.

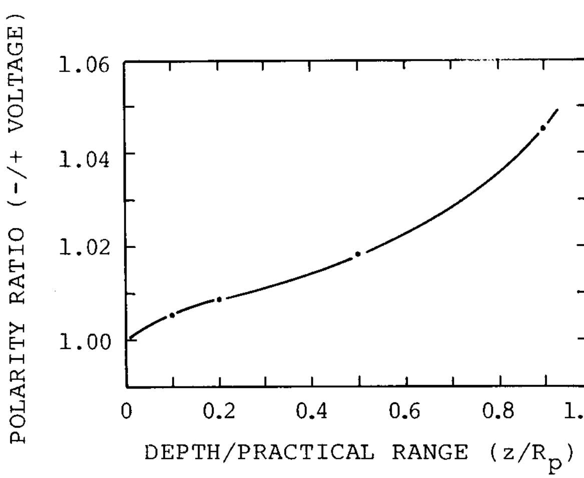

Figure 3: Polarity effect of the ionization chamber in an electron beam of 10 MeV.