DESIGN AND CONSTRUCTION OF AN EXTRAPOLATION CHAMBERFOR DOSIMETRY OF DERMATOLOGICAL APPLICATORS

Dias, S.K. and Caldas, L.V.E.

Instituto de Pesquisas Energéticas e Nucleares
Comissao Nacional de Energia Nuclear
Sao Paulo, Brazil

Abstract.

A plane parallel ionization chamber of variable air volume was designed and constructed. This chamber is simple, easily made and of low cost. The collecting electrode (3.0mm diameter and 4.0mm thickness) and the guard-ring (6.0mm diameter) were made of graphite. A Keithley 617 electrometer was used as measurement assembly. Extrapolation curves were obtained with the chamber at 3 and 30cm source-detector distances. This chamber is intended to measure dose rates of clinical applicators, but the extrapolation chamber was initially tested at the calibration conditions of a beta secondary standard system. The obtained results of the short and medium term stabilities, the saturation curve, and the response variation with the source-detector distance were compared with those of commercial chambers.

1. Introduction.

Sealed radioactive sources have been used for the treatment of superficial eye disorders and skin superficial lesions. An applicator containing 90Sr+90Y was first used clinically by Friedell in 1950. The advantages of such applicators are the very low gamma ray contamination possibilities and the absence of gaseous decay products, as well as the short range of the beta rays of this kind of source(1). The calibration methods include the use of extrapolation ionization chambers, photographic films, scintillators or thermoluminescent detectors(2). The extrapolation chamber is considered to be the most accurate instrument for this case, but there is no international agreement upon calibration procedures(3,4).

The extrapolation chamber is a plane parallel ionization chamber with a variable cavity volume. Since its introduction by Failla in 1937, it has taken many forms, and some modifications have been reported(4,5,6).

An extrapolation chamber was designed and constructed with the objective to detect beta radiation of dermatological applicators. This chamber is intended to be used for dose rate measurements of clinical applicators with active areas of 2.0 cm^2. These measurements shall be taken with the chamber positioned so near as possible of the source. Initially the extrapolation chamber was studied at the calibration conditions of a beta secondary standard system.

2. The Extrapolation Chamber Project.

The developed chamber has a collecting eletrode (3.0mm diameter and 4.0mm thickness) and aguardring (6.0mm diameter) of graphite. Teflon was used as insulating material between the electrode and the guardring. The entrance window was made of aluminized Mylar with 0.84mg.-cm-2 of superficial density.

A Keithley 617 electrometer was used as measurement assembly. The measured ionization current values were corrected for the air density (temperature and pressure). The 90Sr+90Y source (1850MBq) of the beta secondary standard system, with a calibration certificate from PTB, Germany, was used for the preliminary tests of this study.

3. Results.

a. Extrapolation Curve.

An extrapolation curve was obtained with the chamber at a 30cm distance from the source. The ionization current was measured varying the chamber depth (electrode separation distance in the chamber) between 0.7 and 2.5mm, keeping the electric field constant at 10V/mm. For this study ten consecutive measurements were taken for the positive and negative polarities. This experiment was also repeated for the source--detector distance of 3.0cm. In both cases a linear relationship between the current values and the air volume was verified. The obtained real null interelectrode distance was 0.045mm (Fig. 1).

b. Short and Medium Term Stabilities.

The chamber was positioned in a reproducible manner in relation to the radioactive source and ten consecutive measurements were taken for the short term stability determination. The obtained variation coefficient was 0.26%. For the medium term stability test 12 daily measurement series were realized. A variation coefficient of 0.25% was obtained. The mean values were within +1% of the reference value, which is in agreement with the IEC recommendations(7).

c. Saturation Curve.

The saturation curve was determined varying the applied voltage to the chamber between 0.5 and 10V. Ten consecutive ionization current measurements were taken for each polarity. The source--detector distance was 11cm and the chamber depth was kept constant at 1.0mm.

The saturation curve can be seen in Fig.2. An initial rapid increase in the ionization current with the voltage is observed; after about 10V the ionization current increases slowly with the voltage, tending to a saturation.

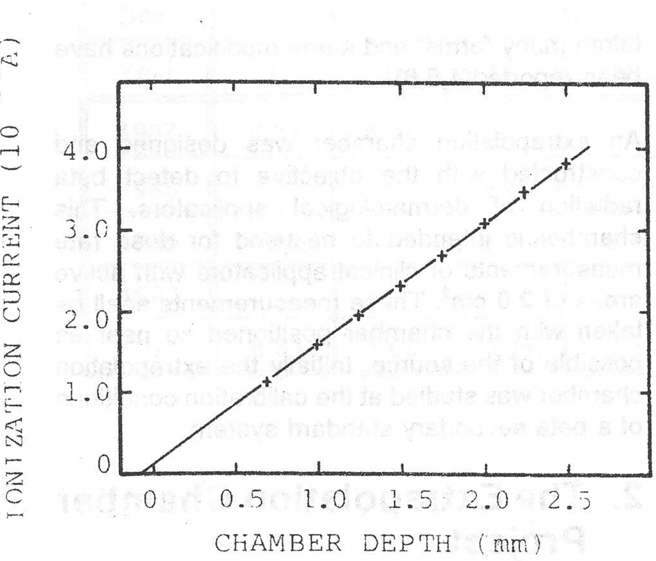

Fig.1 Extrapolation curve, measurements taken at 30cm from the 90Sr+90Y source.

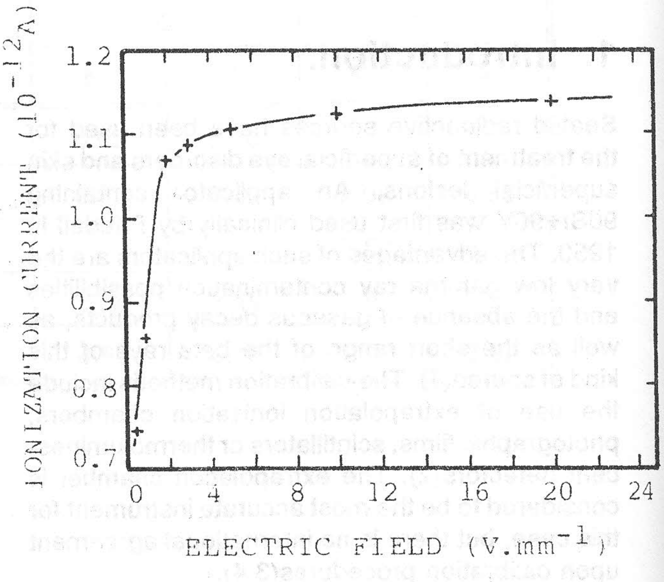

Fig.2 Saturation curve of the extrapolation chamber. 90Sr+90Y source-detector distance: 11cm.

d. Response Variation with the Source-Detector Distance.

Ionization current measurements were taken varying the source-detector distance between 5 and 80cm, in order to establish alternative calibration conditions.

The applied voltage and the chamber depth were kept constant at 10V and 1.00mm respectively. The ionization current values varied between 5.6x10-12A and 2.1x10-14A. The square root distance law was verified (Fig. 3).

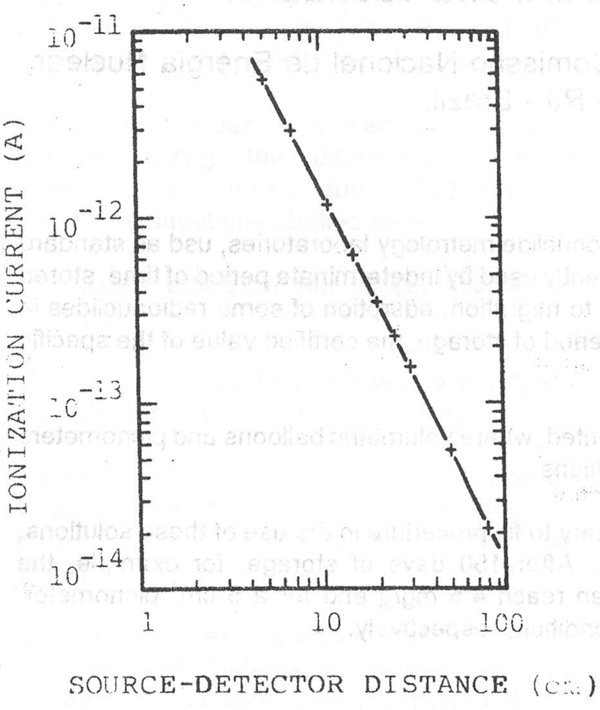

Fig.3 Response variation with the 90Sr+90Y source-detector distance.

4. Conclusion.

The calibration and the routine activity control of clinical applicators involve complex processes and they are realized by only few laboratories. In the present work the construction and development of an extrapolation chamber for dosimetry of beta applicators was described. The chamber is simple, easy to operate, and of low cost.

The performed tests at the calibration conditions of the 90Sr+90Y source of the beta secondary standard system showed results comparable to those of commercial chambers. Some preliminary tests realized at the calibration conditions of dermatological applicators (chamber positioned so near as possible from the applicator) indicate the feasibility of this extrapolation chamber project.

Acknowledgments.

The authors acknowledge the valuable technical assistance of Mr.Marcos Xavier and the financial support of Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

5. References.

1. Goetsch,S.J. and Sunderland, K.S., Surface Dose Rate Calibration of 90Sr Plane Ophthalmic Applicators", Med. Phys., 18(4) 787-794, 1991.

2. Sayed,J.A. and Gregory,R.C. A New Method for Characterizing Beta Ray Ophthalmic Applicator Source, Med. Phys., 18(3) 453-461, 1991.

3. Rest,C.S., Kuchnir,F.T., Rosenberg,I., Myrianthopoulos,L.C. Dosimetry of 90Sr Ophthalmic Applicators, Med. Phys., 17(4) 641-646, 1990.

4. Soares, C.G. Calibration of Ophtalmic Applicators at NIST: A Revised Approach, Med. Phys., 18(4) 787-793, 1991.

5. Payne, W.M. and Waggener, R.G. An Extrapolation Chamber for the Calibration of Beta-Ray Applicators, Med. Phys., 5(3) 165-166, 1974.

6. Loevinger,R.andTrott,N.G. Design and Operation of an Extrapolation Chamber with Renovable Electrodes,Int.J.Appl. Rad. Isot., 17 103-111, 1966.

7. International Electrotechnical Commission, Medical Electrical Equipment Dosimeters with Ionization Chamber as used in Radiotherapy, Geneva, 1982 (IEC-731-82).