RESULTS ON $^{90}Sr + ^{90}Y$ APPLICATORS DOSIMETRY USING EXTRAPOLATION CHAMBERS

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ABSTRACT

The characteristics of four extrapolation chambers designed and constructed at the Calibration Laboratory of São Paulo were studied in this work. The relationship between the collecting electrode size and the entrance window density with the estimated absorbed dose-rate was investigated. Comparison with the Amersham calibration certificate indicate surface dose-rates agreement within 5%.

INTRODUCTION

^{90}Sr applicators have been successfully used for the treatment of superficial lesions. Different calibration techniques such as TLD, radiochromic dye films, fixed volume ionization chambers and scintillators have been reported (1,2). Nevertheless, significant discrepancies in the calibration of this sources are still observed (3).

At the Calibration Laboratory of São Paulo, four extrapolation chambers were projected and constructed with the aim of calibrate dermatological applicators. In this work, the influence of several parameters including the choice of the collecting electrode diameter and the entrance window density in the measurements of absorbed dose-rate was investigated. The absorbed dose rate of a $^{90}Sr + ^{90}Y$ beta radiation applicator was obtained using the different chambers, and the results were compared.

MATERIAL AND METHODS

The developed extrapolation chambers have a collecting electrode and a guard-ring of graphite. The chamber bodies are of Lucite and the entrance window of aluminized Mylar. Lucite was also used as insulating material between the electrode collector and the guard-ring . The main characteristics of the chambers are presented in Table1.

Table 1 Characteristics of the IPEN Extrapolation Chambers

Chamber	Collecting Electrode Diameter (mm)	Entrance Window Superficial Density ($mg.cm^{-2}$)	Effective Area (mm)
C1	10	0.84	78.5
C2	10	6.42	78.5
C3	3	6.42	8.30
C4	3	0.84	8.30

A Keithley 617 electrometer was used as measurement assembly. The applicator of the present study was from Amersham, Model SIQ, containing 1480MBq (1968) of $^{90}Sr + ^{90}Y$. The absorbed dose-rate in tissue ($7mg.cm^{-2}$) quoted by the manufacturer on 8.11.68 and corrected for the decay time to the measurement day and for the recent values of $\overline{W}/e$ and S_{air}^{tissue} is 31.01 $mGy.s^{-1}$.

RESULTS

a. Transmission Factors

The transmission factors were obtained covering the chambers with the polyethylene therephthalate (Hostaphan) foils and Plexigles plates with different thicknesses. The measurements were realized with the $^{90}Sr + ^{90}Y$ applicator placed as near as possible of the chambers and also at a distance of 1,0cm. The maximum relative standard deviation in these measurements was 1%.

The transmission factors determined for typical values of the tissue equivalent material with the chamber C4 are presented in Table 2. Similar results were verified with the other chambers; a comparison between the obtained transmission factors showed a difference lower than 1%. The results of Table 2 also indicate that, for a null source-detector distance (a=0), the effect of adding 7mg.cm^{-2} of plastic to the extrapolation chambers has been found to lower the measured dose rate by about 5%.

Table 2. Transmission factors for beta radiation $^{90}Sr + ^{90}Y$
a: Chamber C4-source distance

Tissue Thickness mm	Superficial Density mg.cm^{-2}	a = 0	a = 1cm
0	0	1.000	1.000
0,02	2	0.984	1.002
0,04	4	0.972	1.008
0,05	5	0.968	1.010
0,07	7	0.956	1.012
0,10	10	0.936	1.016
0,20	20	0.888	1.020
0,50	50	0.748	0.992
1,00	100	0.554	0.816

b. Absorbed Dose-Rates to Tissue

The absorbed dose rates to tissue were determined from current measurements at air gaps from 0.10 to 0.30mm. The measurements were realized with the applicator positioned as near as possible from the chambers. The extrapolation curves were obtained measuring the ionization current for both potential polarities applied to the chambers and plotting the average of this values as a function of the chamber depth. A linear function was fitted to the current-versus-air-gap data and the slope was used to determine the average surface-absorbed-dose-rate over the central area of the source. A constant potential gradient of 100V/mm was employed for all air gaps.

The absorbed dose rate to tissue in Gy/s is given by (3):

$$\dot{D}_Z = \frac{(\overline{W}/e).S_{air}^{tissue}}{\rho_0.A}(\frac{\Delta I_c}{\Delta d}) \quad (1)$$

where $\dot{D}_Z$ is the absorbed-dose rate to tissue at depth z, $\overline{W}/e$ is the average energy required to produce an ion pair in dry air (33.97 J/C), S_{air}^{tissue} is the ratio of the average mass stopping power of tissue to air (1.12), ρ_o is the density of dry air at reference conditions of 22 °C and 101.3kPa, A is the area of the collecting electrode and $(\frac{\Delta I_c}{\Delta d})$ is the fitted slope of the corrected current versus air gap function. The transmission factors were applied in the determination of the absorbed-dose rate at 7mg.cm^{-2}.

The uncertainties in this procedure include the measured $(\frac{\Delta I_c}{\Delta d})$ ratio as well as the uncertainties in the chosen values for the average energy per ion pair, the stopping power ratios and other correction factors. The overall uncertainties of the absorbed dose rates were estimated to be approximately 13%. Table 3 presents the obtained results of the four chambers.

Table 3. Absorbed dose rate to tissue at 7mg.cm^{-2}

Chamber	$\dot{D}_m$ (mGy.s^{-1})	Δ (%)
C1	30.91	0.3
C2	30.85	0.5
C3	30.18	2.7
C4	30.98	0.1

where:

$\dot{D}_m$: absorbed dose rate to tissue at 7mg.cm^{-2} obtained experimentally;

Δ: percentual difference between $\dot{D}_m$ and $\dot{D}_c$ for the null distance.

Comparing the absorbed dose rates to tissue, determined using the four chambers with those of the source calibration certificate, corrected for the more recent values of $\overline{W}/e$ and S_{air}^{tissue}, a maximum percentual difference of approximately 2.7 % was verified.

CONCLUSION

The results show that the dose-rate determination using the developed extrapolation chambers are in agreement with the Amersham evaluations (corrected for the recent constants) with the overall uncertainties. In this study, the influence of the collecting electrode size of the chambers was negligible. However, in this case all chambers used an electrode smaller than the source size. The comparison between the results obtained with the four chambers indicate a percentual difference lower than 3%, showing a good agreement. From the experiments, it was also verified that the dose rate for tissue irradiation falls off by approximately 5% between the surface and a depth of 7mg.cm^{-2}.

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