ON THE CALIBRATION OF PARALLEL PLATE ON IONIZATION CHAMBERS FOR LOW-ENERGY X-RAY BEAMS

por

Sergio Luiz Piubeli[1] e Lea Contier de Freitas[2]

ABSTRACT -- The two secondary standard dosemeters available at the National Laboratory of Ionizing Radiation Metrology (LNMRI) for calibration of parallel plate chambers used in the dosimetry of low-energy X-ray beams have calibration factors for beam qualities up to 50 kV and half-value layer (HVL) of 2.257 mm Al. Since many superficial therapy X-ray tubes operate at 60 kV, for example the Chaoul tube which generates a beam of HVL equal to 3.3 mm Al, there is a demand of calibration of such chambers in beams generated at this potential. This work, aiming at the calibration of parallel plate chambers at 60 kV, evaluates the difference of the exposure rate, at the same point, for two low-energy beam qualities (HVLs equal to 0.5 and 1.0 mm Al respectively), as determined by a parallel plate and a cylindrical standard chambers which have calibration factors for this energy range.

INTRODUCTION

The two secondary standard dosemeters available at the National Laboratory of Ionizing Radiation Metrology (LNMRI) for calibration of parallel plate chambers used in the dosimetry of low-energy X-ray beams have calibration factors for beam qualities up to 50 kV and half-value layer (HVL) of 2.257 mm Al. Since many superficial therapy X-ray tubes operate at 60 kV, for example the Chaoul tube which generates a beam of HVL equal to 3.3 mm Al, (BJR 17,1983), there is a demand of calibration of such chambers in beams generated at this potential. In general, chambers should be calibrated against others of similar design mainly because of the contribution of scattered radiation. However, for low-energy photons, the photoelectric effect predominates and the contribution of scattered photons to the ionisation in the chamber's measuring volume should be negligible, thus allowing the use of a cylindrical chamber in the calibration of parallel plate chambers. However, the attenuation of the photons

[1]-Presently at Physics Department, Universidade Federal do Mato Grosso do Sul, Campo Grande, MS.

[2]-Laboratorio Nacional de Metrologia das Radiacpes Ionizantes Instituto de Radioprotecso e Dosimetria Caixa Postal 37750 - 22642 - Rio de Janeiro-RJ - Brasil

by the wall of the cylindrical chamber is very much different to that by the plate chamber's window since they significantly differ in thickness. This work evaluates the difference of the exposure rate, at the same point, for two low-energy beam qualities (HVLs equal to 0.5 and 1.0 mm Al respectively), for which both the parallel plate and cylindrical standard chambers have calibration factors, aiming at the calibration of parallel plate chambers at 60 kV.

MATERIAL AND METHODS

The X-ray beams characterised in table 1 were generated by a Philips MG 160 tube which has a 1 mm thick Be window. The nominal volume of the parallel plate chamber Nuclear Enterprise (NE) 2532-3/171376 is 0,03 cm^3 while that of the cylindrical chamber NE 2561/264 is 0,325 cm^3 . Both chambers were calibrated at the National Physical Laboratory (NPL), England, and their calibration factors are also shown in table 1. The chambers were respectively connected to a NE 2500-3/1695 and to a NE 2560/212 electrometers. The centre of the chambers were positioned alternately in the centre of a 7.6 cm diameter field at 50 cm from the focus. The readings taken were corrected for the reference temperature of 20°C and pressure of 101.3 kPa and multiplied by the respective calibration factor in order to obtain the exposure rate. Time was measured with a NE 2546 digital chronometer.

Table 1 - X-ray qualities and chambers' calibration factors

Tube potential (kV)	34.0	47.4
Additional filtration (mm Al)	0.690	1.11
Half-value layer (mm Al)	0.505	0.994
Calibration factor (mR nC^{-1})		
parallel plate	113.2	112.7
cylindrical	11.30	10.65

RESULTS

Table 2 shows the exposure rate at 50 cm from the beam focus as determined for the two X-ray qualities in question. The values presented are the mean of 10 measurements whose percentual standard error was equal to or smaller than 0.12%.

Table 2 - Comparison of exposure rate as determined by a parallel plate and a cylindrical chambers

Tube Potential (kV)	HVL (mm Al)	Exposure rate ($mR\ min^{-1}$) parallel plate	cylindrical	Difference (%)
34.0	0.505	13.8	13.5	2.1
47.4	0.994	15.0	14.7	1.9

CONCLUSION

The difference between the exposure rates as determined by the towtypes of chambers was around 2% for the two X-ray qualities. It can be thus assumed that the calibration of a plate parallel chamber against a cylindrical one for X-ray qualities of HVL larger than 1 mm Al would also incur in a systematic error of the same order. If thisi additional uncertainty of 2% is acceptable in the calibration of parallel plate chambers, bearing in mind the dosimetric application they have in superficial radiotherapy, then such chambers could be calibrated against the standard cylindrical chamber for the 60 kV quality. However, it should be warned that such comparison procedure is only meaningful in a standardisation laboratory, under the above established calibration conditions, and attempts to measure the outful of low-energy X-rays beams in the hospital with cylindrical chambers should be avoided.

REFERENCE

BJR 17, 1983 - Central Axis Depth Dose Data for Use in Radiotherapy, British Journal of Radiology, Suppl. 17:9