CALIBRATION OF PARALLEL PLATE IONIZATION CHAMBERS IN DIFFERENT KINDS OF RADIATION

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ABSTRACT

Parallel plate ionization chambers designed and constructed for use in low energy X-radiation fields were tested in beta ($^{90}Sr + ^{90}Y$), gamma (^{60}Co and ^{137}Cs) and intermediate energy X-radiation, in order to verify the possibility of their usefulness for the detection of these kinds of radiation. The obtained calibration factors were compared with those of the secondary standards of each type of radiation.

INTRODUCTION

Different types of ionization chambers are normally used depending on the kind of radiation. The parallel plate ionization chambers are recommended for low energy X-radiation dosimetry[1,2]. However some interest has been already shown in the use of such chambers in other kinds of radiations[3,4]. The objective of this work was to verify how to use these chambers in beta, gamma and intermediate energy X-radiation, in order to avoid the necessity of accquisition of several chambers.

EXPERIMENTAL MEASUREMENTS

Two parallel plate ionization chambers A and B, of circular form, with Lucite bodies, active volumes of 0.6 cm^3, graphite collecting electrodes and guard-rings, designed and manufactured at IPEN[5,6], were tested at three different laboratories. Chamber A was examined in Brazil, using the irradiation systems of the calibration laboratories of São Paulo (IPEN) and Rio de Janeiro (Instituto de Radioproteção e Dosimetria - IRD), and chamber B was calibrated at the Secondary Standard Dosimetry Laboratory of Neuherberg, GSF, Germany (Institut für Strahlenschutz). In each case the chamber response was compared with that of a corresponding secondary standard chamber. The standard deviation of all these measurements was lower than 0.20%.

For low energy X-radiation the obtained calibration factors for the chamber A can be seen in Table 1 in comparison to those of the secondary standard ionization chamber (P) for this energy range. Both chambers A and P are of the superficial type. The energy dependence of chamber P presents a variation of 1.9%, while it is only 0.3% for chamber A.

In the case of intermediate energy X-radiation, the calibration factors for the chamber A are presented in Table 2. Chamber T is the secondary standard chamber (thimble type) recommended for this kind of radiation. It can be seen that chambers A and T show variations of 5.7 and 2.1% respectively for the energy dependence in the considered range.

In order to test the chamber A in gamma radiation fields, at the laboratory of São Paulo, a ^{60}Co Keleket Barnes Flexaray and a ^{137}Cs Cesapan-M, Generay, were used. At the German laboratory GSF a Gammatron and a Theratron were employed with the chamber B. Initially the electronic equilibrium thickness had to be determined, taking measurements for different Lucite absorbers: 3.3 mm (^{60}Co) and 1.2 mm (^{137}Cs). The obtained results are shown in Table 3, normalized to ^{60}Co response (because different electronic equipments were used), in comparison to commercial chambers (superficial and thimble). All chambers were calibrated against the normally utilized secondary standard for gamma radiation. The greateast energy dependence was presented by the chamber C (1,2%); chambers A and B show similar behaviours to that of chamber D, which is of the recommended type (thimble) for gamma radiation.

In the case of beta radiation the $^{90}Sr + ^{90}Y$ sources of the secondary standards of the calibration laboratories of IPEN and GSF were utilized. The reference instrument for this kind of radiation is the extrapolation chamber (E). In Table 4 the calibration factors are presented.

CONCLUSION

The obtained results show the usefulness of the parallel plate ionization chambers developed at IPEN for X, gamma and beta radiation detection.

REFERENCES

1. IAEA, 1987, International Atomic Energy Agency. Absorbed Dose Determination in Photon and Electron Beams. An International Code of Practice, Vienna, Technical Report Series 277.

2. IAEA, 1979, International Atomic Energy Agency. Calibration of Dosemeters used in Radiotherapy, Vienna, Technical Report Series 185.

3. Keys, D.J. and Purdy, J.A., 1980, Thin-walled Parallel Plate Ionization Chamber for Use with Photon and Electron Beam Dosimetry, Med. Phys. 7 (2) 163-164.

4. Kooy, H.M., Simpson, L.D. and McFaul, J.A., 1988, Parallel Plate Ionization Chamber Response in Cobalt-60 Irradiated Transition Zones, Med. Phys. 15 (2) 199-203.

5. Albuquerque, M.P.P. and Caldas, L.V.E., 1989, New Ionization Chambers for Beta and X-Radiation, Nucl. Instrum. Meth.Phys. Res., A 280, 310-313.

6. Caldas, L.V.E., 1991, A Sequential Tandem System of Ionization Chambers for Effective Energy Determination of X-Radiation Fields, Radiat. Prot. Dosim. 36 (1) 47-50.

TABLE 1

Calibration factors of chambers A and P (secondary standard NPL model 2536/3B, superficial type) for low energy X-rays. Calibration Laboratory, IPEN, São Paulo X-ray system: Geigerflex, Rigaku Denki su: scale unit

Half-Value Layer (mmAl)	Calibration Factor $R.su^{-1}(10^{-4}C.kg^{-1}.su^{-1})$ Chamber A	Chamber P
0.37	1.061 (2.74)	0.919 (2.37)
0.56	1.063 (2.74)	0.911 (2.37)
0.65	1.063 (2.74)	0.908 (2.37)
0.91	1.064 (2.75)	0.902 (2.33)

TABLE 2

Calibration factors of chambers A and T (secondary standard ÖFS, model TK01, thimble type) for intermediate energy X-rays. Calibration Laboratory, IRD, Rio de Janeiro
X-ray system: Stabilipan 300, Siemens
su: scale unit

Half-Value Layer (mmAl)	Calibration Factor $R.su^{-1}$ ($10^{-4}C.kg^{-1}.su^{-1}$) Chamber A	Chamber T
0.06	1.023 (2.64)	0.877 (2.26)
0.16	0.996 (2.57)	0.866 (2.23)
0.50	0.970 (2.50)	0.864 (2.23)
1.00	0.968 (2.50)	0.862 (2.22)
2.02	0.988 (2.55)	0.859 (2.22)

TABLE 3

Energy dependence of chambers A, B, C (NE model 2532/3, superficial type) and D (NE 2505/3, thimble type) for gamma radiation

Source	Chamber A	B	C	D
^{60}Co	1	1	1	1
^{137}Cs	1	0.995	0.988	1.005

TABLE 4

Calibration factors of chambers A, B, P and E (extrapolation chamber PTW model 23391) for beta radiation of ^{90}Sr + ^{90}Y

Chamber	A	B	P	E
Calibration Factor $cGy.su^{-1}$	0.835	0.728	0.663	0.748