COMPARISONS INHOMOGENEITY OF PHOTON FIELDS AND BACKSCATTER FACTORS FOR PMMA AND WATER SLAB PHANTOMS

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ABSTRACT

The dose rate distributions of photon fields for calibrating personal dosimeters are measured free-in-air and in front of the PMMA and water phantoms. The backscatter factors and relative inhomogeneity of photon fields at both of phantoms are compared. From radiation protection aspect, for the hospital staff at Rö diagnostics, we have discussed the preferences and defects on the occasion of use for everyone of phantoms separately. It turned out that in to give the objective opinion for occupational health, we have to consider to the positioning of the personnel dosimeter during their calibration in photon fields X ray apparatus of the Standard Dosimetry Laboratory.

INTRODUCTION

In the many investigations, it were appearing that the staff at Ro diagnostics and radiotherapeutics division have been greatly depending of coordinates extent in ionization irradiation fields. On another side, the individual dosimeters have calibrated on the conventional phantoms and in defined reference radiation fields. Instantaneously, the ICRU recommendations have referred one to the phantoms, like a sphere or a slab with tissuequivalent matter or simply Plexiglas (PMMA,polymethyl methacrylate) (1,2). The slab phantom is better for perceive the extent inhomogeneity fields. In as much it's envisaging angular and energy distributions of the photon flux in a longitudinal direction parallel to primary radiation beam, a buildup factor is significant. In a lateral direction, perpendicular to primary beam, a backscatter factor is representative (4,5). In both cases, it's adopting that the photon backscatter is minor from room's wall. Finally, should be establish influence of anisotropy angular distribution of emitted photons from the target X ray tube and contribution of the photon backscatter at the total field profile on the front phantom, on account of the primary radial beam. At the same time, should be see and the good reason for the water phantom utilization.

EXPERIMENTAL MEASUREMENTS

Firstly, all measurement results have concerned at exposure dose rate. The measurements are performed by X ray apparatus with conditions for maximal exposure dose rate at all mean energy photon spectra (6). We have used ionization chambers made by PTW-FREIBURG, volume 0,2 cm^3, 1 cm^3 and 30 cm^3, uncertainty in measurement ± 2%. Constant potential X ray system MG 320 Philips with metal-ceramic tube MCN321, can generate direct voltage in the range from 30 kV to 320 kV. Other technical data are: anode angle 22^0, inherent filtration 2,2 mmBe and standard focus 4mm x 4mm. It is existing possibility that conventional mean energy X ray spectra are reproduced by the beam passes through selective filters disc. The beam quality have been accord with the requirements of international standards (3,6). Dimensions water and PMMA (density 1200 kg/cm^3) phantoms were 20 cm x 20 cm x 15 cm. On the occasion of those measurements exposure dose rate at focus-phantom distance 1,5 m , beam diameter was 25 cm. However, measurement results at an edge of the phantom exist insecure for real conclusions because the border effects change backscatter factor for different mediums.

RESULTS AND DISCUSSION

Maximum lateral distribution free-in-air, perpendicular to the beam axis and parallel to the tube axis (PLD), with increasing voltage (60kV-300kV) shifts to the "anode side" (fig.1). For fixed voltage of 300 kV , (fig.2), an alteration lateral profile for different filtration are demonstrated /A30(4 mmAl + 2,2 mmBe, A0(2,2 mmBe)/. The most unfavorable field profile exist for very heavy filtration and high tube

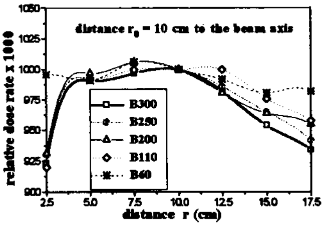

figure 1. PLD free-in-air for different tube voltages

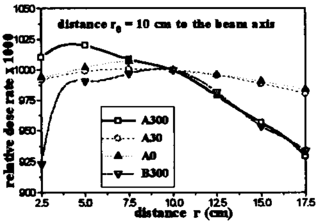

figure 2. PLD free-in-air for different filtrations at 300 kV

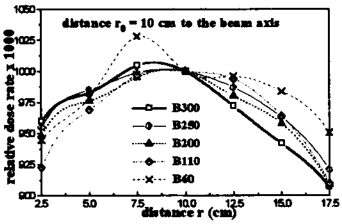

figure 3. PLD in front water phantom for different tube voltages

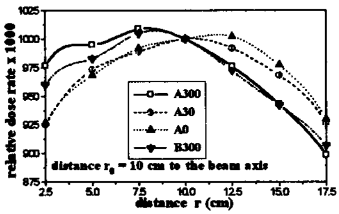

figure 4. PLD in front water phantom for different filtrations at 300 kV

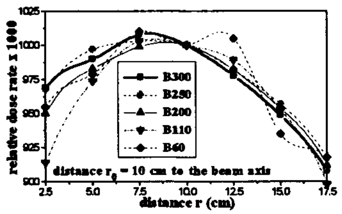

figure 5. PLD in front PMMA phantom for different tube voltages

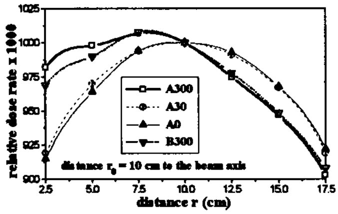

figure 6. PLD in front PMMA phantom for different filtrations at 300 kV

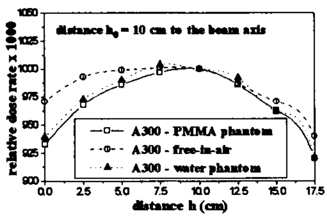

figure 7. NLD in front phantoms and free-in air for HFHV conditions

voltage (HFHV conditions as A300 and B300). Lateral distribution in the direction perpendicular to the tube axis (NLD) is smooth, but asymmetrical to the center field because there are the photon scatter from the bench measuring (fig.7).

Table 1. Radiation qualities of calibration fields and backscatter factors for PMMA and water slab phantom

Code/high voltage (kV)	Additional (#) filtration (mm) Al	Cu	Sn	Pb	Mean Energy (keV)	Backscatter factor for phantom PMMA	WATER
Narrow spectra							
A60	4.0	0.6	-	-	45	1.32	1.28
A100	4.0	5.0	-	-	82	1.38	1.37
A150	4.0	-	2.5	-	115	1.27	1.24
A200	4.0	2.0	3.0	1.0	155	1.18	1.17
A250	4.0	-	2.0	3.0	210	1.14	1.13
A300	4.0	-	3.0	5.0	250	1.13	1.12
Broad spectra							
B60	4.0	0.3	-	-	43	1.31	1.27
B80	4.0	0.5	-	-	55	1.33	1.29
B110	4.0	2.0	-	-	78	1.40	1.38
B150	4.0	-	1.0	-	105	1.32	1.30
B200	4.0	-	2.0	-	135	1.23	1.22
B250	4.0	-	4.0	-	170	1.18	1.16
B300	4.0	-	6.5	-	200	1.14	1.13

(#) Inherent filtration 2,2 mm Be.

In front of the water and PMMA phantom, on account of divergence beam, values backscatter factor are smaller than for "ideal" parallel beam. It's very significant fact since exposure dose rate profiles are created by local distribution of the photon backscatter. Maximum backscatter yield is for 82 keV (narrow spectra) and for 78 keV (broad spectra) , Table 1. It's finding out the most steep slope at the field profile for B110 (fig. 3 and 5). The symmetry PLD is loosed at extreme irradiation HFHV conditions on account of photon anisotropy emission by X ray apparatus (fig. 4 and 6). Then profile is spreaded evenly to the "anode side", because local diminution photon backscatter is compensated by yield of angular anisotropy emission. There are recommendations (2,3) that permissible inhomogeneity is less than 5%. For all energies in Table 1, at the front slab water phantom those express request have accomplished from 5 to 12,5 cm, until for slab PMMA phantom from 3,75 to 13,75 cm. As for NLD, the symmetry is peculiar and influence of photon scatter from bench measuring is slight. Inhomogeneity within 5% is tolerated from 2,5 to 15 cm above bench (fig.7).

CONCLUSIONS

Prior to employment modern X ray apparatus in the Standard Dosimetry Laboratory should be acquainted the profiles of photon fields for calibrating. At the base well known dimensions of the individual dosimeters (TLD, RPL, film and pMOS solid state) it can project and execute the conventional calibration. One fact is worth putting forward, that the region of high homogeneity (greater than 95%) at front PMMA is greater than for front water phantom.

REFERENCES

1. W.Will, Radiation Protection Dosimetry 48(3), 245-249 (1993).
2. ICRU Report 39, Determ. of Dose Equivalents Resulting from Ext.Sources (1985).
3. ISO/DIS 4037 (1976).
4. H.E.Johns,Radiation Dosimetry Vol. III, Eds. F.H.Attix et all., Academic Press(1969).
5. Gad Shani, Radiation Dosimetry, Instrumentation and Methods, 17-39,CRC Press(91).
6. D.Veličković et all., 777-782 (2), JUKEM 13 (1988).