TECHNICAL NOTE

Polarity effect on surface dose measurement for an attix parallel plate ionisation chamber

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Abstract

The effects of chamber polarity have been investigated for the measurement of 6MV and 18MV x-ray surface dose using a parallel plate ionization chamber. Results have shown that a significant difference in measured ionization is recorded between polarities at 6MV and 18MV at the phantom surface. A polarity ratio ranging from 1.062 to 1.005 is seen for 6MV x-rays at the phantom surface for field sizes 5cm x 5cm to 40cm x 40cm when comparing positive to negative polarity. These ratio's range from 1.024 to 1.004 for 18MV x-rays with the same field sizes. When these charge reading are compared to the D_{max} readings of the same polarity it is found that these polarity effects are minimal for the calculation of percentage dose results with variations being less than 1% of maximum.

Key words surface dose , polarity , radiotherapy

Introduction

Parallel plate ionisation chambers are described as being high accuracy measuring devices for the determination of absorbed dose in photon and electron beams produced by linear accelerators for high energy radiotherapy. They are often used for measurement of dose in the build up region of high energy photon beams and in regions of high dose gradient. Some types of parallel plate ionisation chambers have shown a difference in collected charge between one polarity and another when used in the build up region or at depth[1-4]. Gerbi[5] studied the Attix chamber for polarity effects in the build up region for a 10cm x 10cm field size and found a value for the polarity ratio of 0.968 and 0.981 for 6MV and 24MV x-rays respectively during the measurement of surface dose. This work extends the assessment for 6MV and 18MV x-rays to cover field size variations in the polarity ratio and provide analysis on how this effects the actual percentage dose distribution measurements for surface dose assessment.

Materials and methods

The polarity effect for surface dose measurements were performed for 6MV and 18MV x-ray beams produced by a Varian 2100C Linear accelerator. The measurements were performed with a constant source to surface distance (SSD) of 100cm. To determine the polarity effect, measurements were performed for charge collections using positive 250 Volts on a Farmer 2570 dosimeter. After all measurements were taken, the polarity was reversed to negative 250 Volts and the experiments were repeated. A period of ten minutes delay was used between the positive and negative polarity measurements to allow the chamber to stabilise. All measurements were performed 5 times for each field size configuration and at each polarity. These experiments were then re-performed on five separate days. Errors quoted are the combined errors for all experiments performed. Photon beam measurements were made using an Attix Model 449 parallel plate ionization chamber[6] in a solid water[7] stack phantom. Surface dose ionisation was measured along with charge measurements taken at D_{max} for a range of field sizes from 5cm x 5cm up to 40cm x 40cm. Calculation of the polarity ionization ratio (P±) is given by the quotient of the positive polarity ionization and the negative polarity ionization. This is performed at the surface and at D_{max} for various beam configurations and results given along with the percentage surface dose measurements and percentage differences in % surface dose calculated.

Results

Figure 1a shows the polarity ratio for 6MV x-rays with respect to field size at the surface and at the D_{max} position. As can be seen, the polarity effect is quite substantial for smaller field sizes but reduces as the field size increases. The 5cm x 5cm field has a polarity ratio of 1.06 whereas a 30cm x 30cm field value is 1.005. The values for D_{max} are 1.005 and 1.005 respectively. This ratio is relatively

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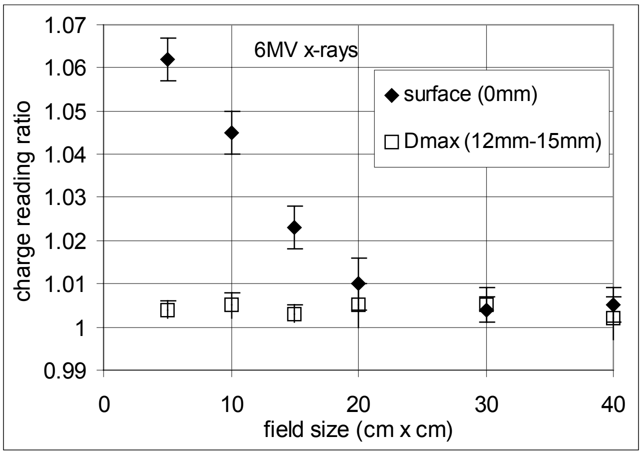

(a)

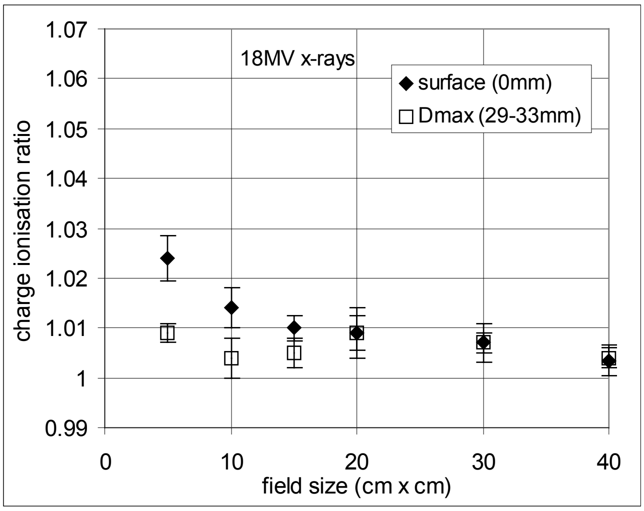

Figure 1. *a) Polarity effect ratio between positive and negative polarity for 6MV x-ray surface ionization measurements at various field sizes. b) Polarity effect ratio between positive and negative polarity for 18MV x-ray surface ionization measurements at various field sizes.*

Field size (cm x cm)	Polarity (250V) +	-	Difference
(6MV results)			
5x5	10.4	9.8	0.6
10x10	16.5	15.9	0.6
20x20	27.2	26.8	0.4
30x30	32.2	31.7	0.5
40x40	42.3	41.8	0.5
(18MV results)			
5x5	7.3	7.0	0.3
10x10	12.6	12.4	0.2
20x20	25.5	25.0	0.5
30x30	33.2	25.0	0.2
40x40	44.1	43.8	0.3

Table 1. *Measured percentage surface dose of maximum*

independent of dose rate (between 100 and 400 Monitor units per minute), applied dose (between 100 and 1000cGy) and the amount of cable within the treatment field. The fact that the ratio is largest for smaller field sizes points towards the effect being mainly due to in phantom produced electrons instead of electron contamination as the smaller field sizes have the least contribution to their dose at the surface from electron contamination. Figure 1b shows the Polarity ratio for 18MV x-rays with respect to field size at the surface and at the D_{max} position. The polarity effect does not produce as large an effect as with 6MV which is consistent to the findings of Gerbi[5] who found a smaller effect with a 24MV x-ray beam compared to a 6MV beam.

Table one shows the percentage surface dose for positive and negative polarity and the measured percentage dose difference for 6MV and 18MV x-rays. As can be seen, even though the polarity ratio is quite large for the smaller field sizes, when compared as a percentage dose of D_{max}, the values become minimal (less than 1% variation). This is specifically due to the low values of ionisation recorded near the surface. When comparing two small charge readings, small differences as a ratio produce a significant figure. However when compared as a ratio to the D_{max} value, the variations are more insignificant. By examining the values for the % dose using the two polarities – very small deviations are seen. These values lie within the standard errors of measurement recorded using the chamber. Analysis using an extrapolation ionisation chamber[5] showed that the Attix chamber produces only a very slight over response in surface dose assessment. This value was calculated as less than 1% for 6MV normally incident beams[6]. The use of both polarities to measure surface dose adds to the labour and time needed to perform such experiments. Due to the fact that the variations recorded are in the order of less than 1% of maximum dose we would advise the following. If there are no time constraints on your chosen measurements then results should be collected at both polarities and averaged when using the Attix chamber for surface and skin dose assessment. If however, you do have a limited time period for data collection due the vast amount of measurements required for surface dose assessment we would advise that minimum inaccuracies are introduced using the Attix chamber for high energy x-ray percentage skin dose assessment. No polarity is recommended above the other as the optimal polarity however; the standard calibration primary polarity used for other chamber calibrations seems a more sensible choice.

Conclusion

There is a polarity effect seen with the use of the Attix parallel plate ionisation chamber for build up dose measurement, which is prominent at smaller field sizes. However, when readings are used as a percentage dose measurement and normalised relative to a value such as D_{max} or dose at 10cm depth, the resulting percentage dose is relatively unaffected within standard errors of measurement.

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