ION RECOMBINATION INVESTIGATION AT A FLASH RADIOTHERAPY FACILITY AT NPL

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Background and aims

Ionisation chambers are exhibiting significant challenges when used in pulsed Ultra High Dose Rate (UHDR) beams due to ion recombination effects. This work aimed to characterise two types of plane parallel ionisation chambers, the PTW Advanced Markus Chamber type 34045 and the IBA PPC05.

Methods

An Elekta Synergy Linac was used, with the 6MV X-ray mode modified to deliver UHDR electron beams. A diode detector (TW60012, PTW) connected to a raspberry-pi based pulse counter was used for beam control. A 10cm × 10cm field size was set at a source-to-surface distance of 56cm with each exposure delivering 600 pulses (dose rate >200Gy/s). The frequency of pulses was 400Hz. Two chambers of each type, connected to a PTW Tango electrometer, were tested between 30 to 400V. The effective point of measurement of all four chambers was placed at the reference depth of 13mm in WTe solid water. The Jaffe plots were used to evaluate the saturation charge

Results

The results are presented in Figures 1,2 and 3 below. The readings are the raw data acquired by the chambers

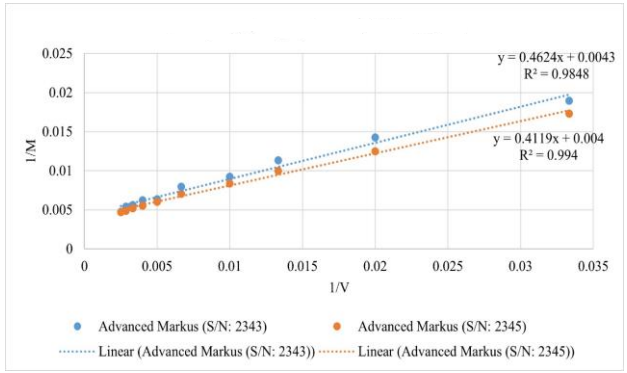


Figure 1. Graph of 1/M as a function of 1/V for the PTW Advanced Markus ionization chamber.

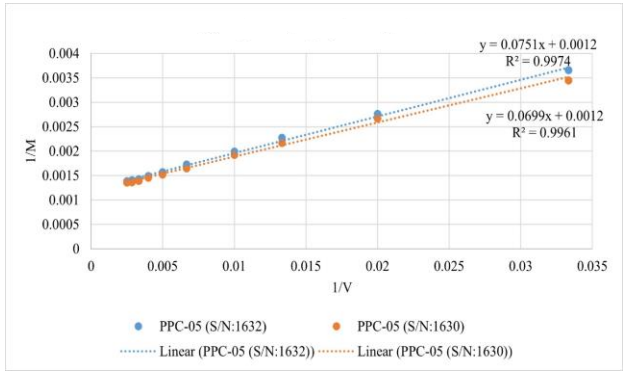
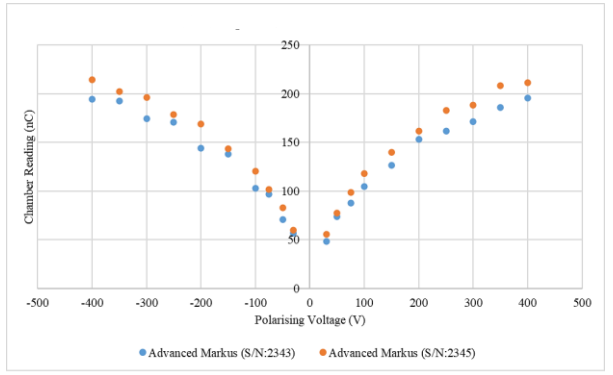


Figure 2. Graph of 1/M as a function of 1/V for the IBA PPC05 ionization chamber.

No temperature and pressure corrections were applied since the changes, on both, observed throughout the day were negligible.



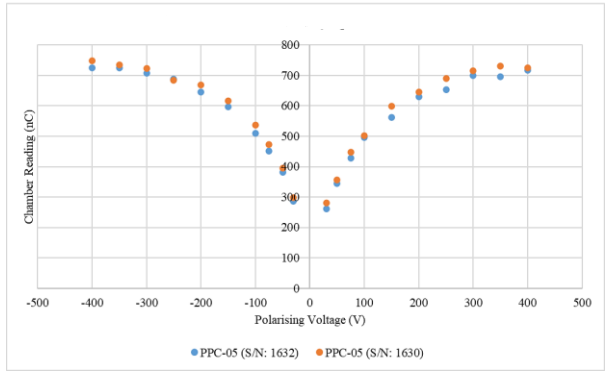


Figure 3. Chamber response with polarising voltage for the PTW Advanced Markus (top) and the IBA PPC-05 (bottom).

Additionally, no electrometer corrections were applied due to the limited number of electrometer calibration points for the positive voltages. Table 1 contains ion recombination correction factors for voltages of interest.

Table 1. Ion recombination correction factors interpolated for 100, 200, 300 and 400V.

Chamber type	K_{ion} (400V)	K_{ion} (300V)	k_{ion} (200V)	k_{ion} (100V)
Advanced Markus (A)	1.095	1.355	1.462	2.130
Advanced Markus (B)	1.176	1.344	1.513	2.097
PPC-05 (A)	1.146	1.207	1.297	1.645
PPC-05 (B)	1.142	1.196	1.279	1.620

Conclusions

All four ionisation chambers presented very good symmetry with a linear behaviour for this range of operating voltages, making the use of the linear extrapolation method suitable for the determination of the saturation charge in these operational conditions. Depending on the applied bias voltage, the ion recombination ranged from 10% up to more than 100% for the PTW Advanced Markus chambers, and from 15% up to 65% for the IBA PPC05 chambers, indicating that these chambers are not suitable detectors for use with UHDR pulsed electron beam dosimetry in the current beam conditions.

Acknowledgements

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1. Douralis, A., et al. "ESTABLISHMENT OF A FLASH RADIOTHERAPY FACILITY AT NPL AND DOSIMETRY STUDY." Physica Medica: European Journal of Medical Physics 94 (2022): S85.