Constancy measurements with a re-purposed water tank electrometer

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INTRODUCTION

The activity of short-lived unsealed sources administered to patients in Nuclear Medicine is measured in a “dose calibrator” (DC). To achieve accurate, isotope-specific, standards-lab-traceable calibration of DCs [1-4], an ion-chamber-based transfer instrument has previously been proposed [5]. The ion chamber is operated by an electrometer, which is here tested for its constancy and reproducibility in order to allow accurate measurement of ionization current.

AIM

To characterize the constancy of a dual-channel scanning tank electrometer when operating a novel calibration ion chamber

METHOD

A dual channel electrometer from a scanning tank (Standard Imaging DoseView) was tested first with a high-ohmic load (1TΩ resistor) and then with a novel design ion chamber in order to test its constancy over time. The electrometer was controlled via its RS-232 serial interface. A Matlab routine was written to implement the electrometer’s binary command set and command frames were sent and received from a desktop PC.

After first zeroing the unit, constancy tests were carried out with a bias of -300V for up to 25 hours.

RESULTS

When connected to the 1TΩ resistor, the electrometer’s current fluctuated by up to ±3 pA over 25 hours. However, the fluctuations are very similar for channel 1 (no load) and 2 (1TΩ load). Subtracting channel 1 from channel 2 reduces the fluctuations to less than ±1 pA (Figure 1). Average current was 317 pA ([channel 2 – channel 1]), yielding a relative uncertainty of <0.4%. The electrometer’s voltage was set to -300 V, which yields a resistance value of 0.96 TΩ, well within the 10% tolerance specification of the resistor used. When connecting the electrometer to the ion chamber after it had first been zeroed, six repeat ‘runs’ showed an initial current spike of ~1.5 pA ([chan. 2 – chan. 1]) which vanished within 2 to 4 minutes; if measurements are taken within 4 to 20 minutes after zeroing the electrometer, current values remained <0.5 pA (Figure 2).

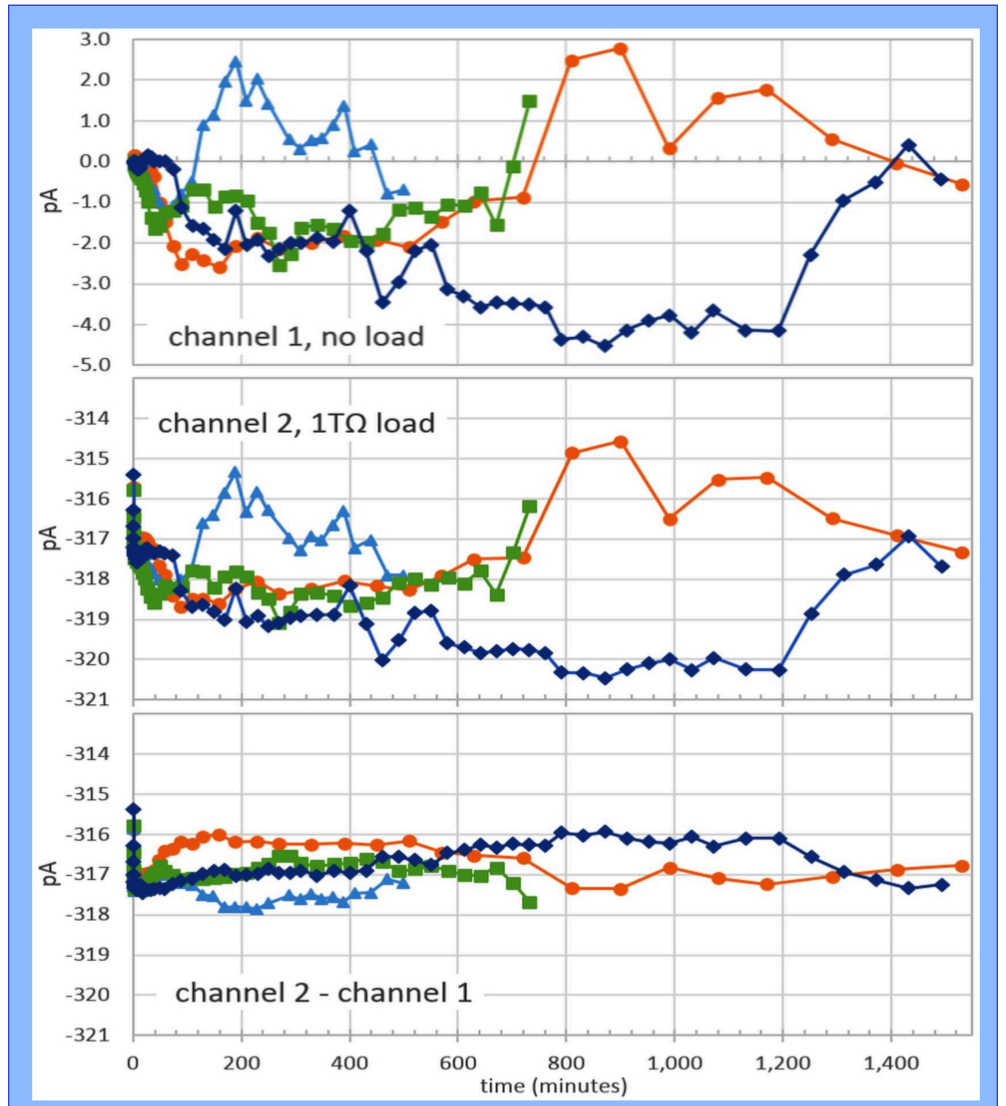

Figure 1: Electrometer operated at -300 V and connected to no load on channel 1 (top) and 1TΩ load on channel 2 (middle); both channels display very similar fluctuations, independent of load. Subtracting channel 1 from channel 2 reduces the fluctuations and current remains constant within ±1 pA over up to 25 hrs (bottom).

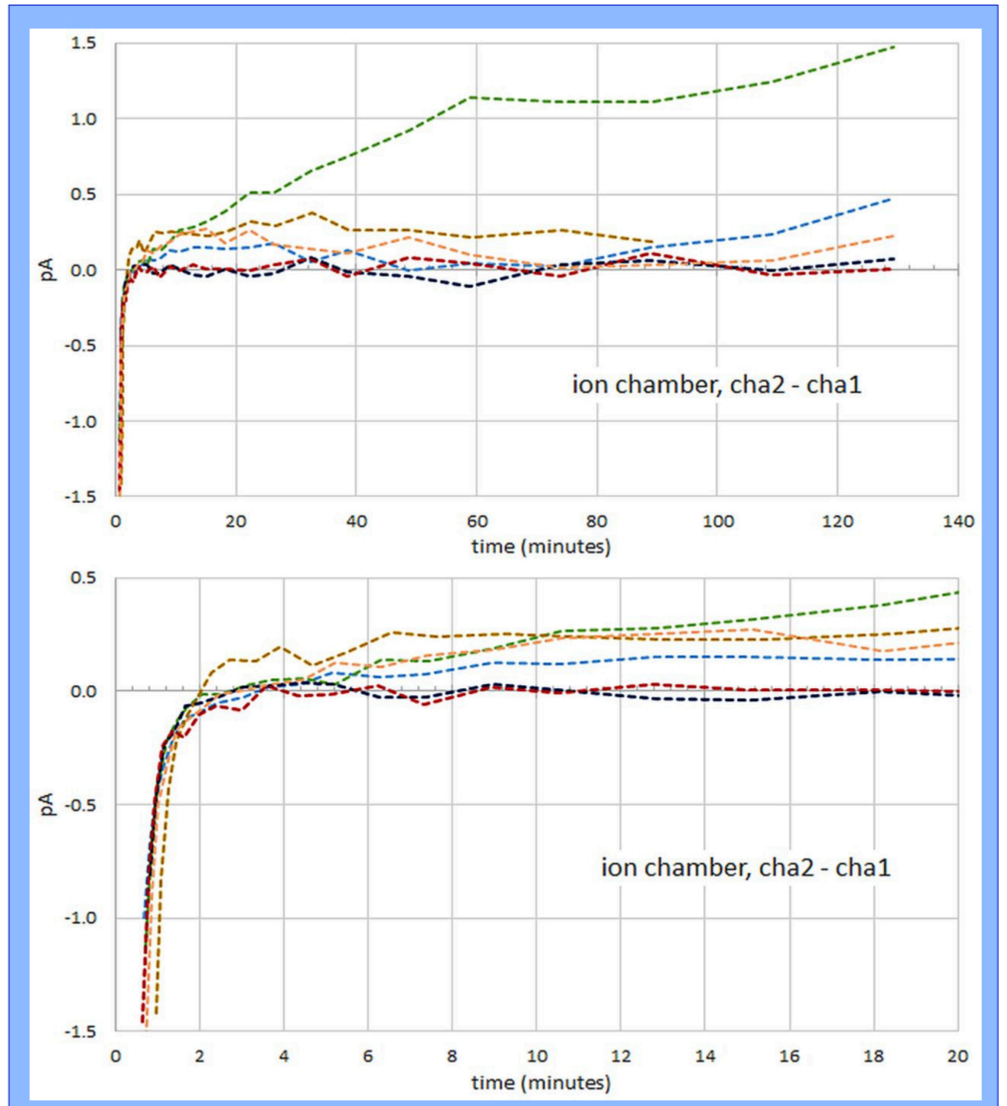

Figure 2: Electrometer connected to no load on channel 1 and the calibration ion chamber on channel 2; shown is the difference [channel 2 – channel 1]; a total of 6 ‘runs’ up to 2 hours after zeroing are shown (top), displaying one ‘outlier’; measurements are reproducible within ±0.3 pA if performed between 4 and 20 minutes.

CONCLUSIONS

Values measured on channel 1 (no load) should be subtracted from channel 2 (load) in order to achieve most consistent results. The electrometer’s constancy is then sufficient to provide reproducible measurements within 0.4% at 300 pA with an ohmic load.

When connecting the ion chamber to the electrometer after first zeroing the instrument, 4 minutes are required until an initial current spike fades and readings reach zero. Readings remain <0.5 pA for up to 20 minutes, at which point ideally the electrometer would be re-zeroed. before taking another reading.

Future tests with radioisotopes will investigate the system under realistic operating conditions.

ACKNOWLEDGEMENTS

The author is grateful to Standard Imaging Inc. (Madison, WI) for providing the electrometer and its interface specifications used in these tests.

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