AbstractID: 3773 Title: A Frequency-domain Approach for Addressing Heat-Transport Problems in Room-Temperature Water Calorimeters

Purpose:
To develop a way to collect and analyze water calorimeter data that enables the use of frequency-domain signal processing techniques for extracting radiation dose signals from waveforms containing artifacts due to conduction and convection. This would provide a convenient, inexpensive way for standards labs to obtain accurate estimates of absorbed dose to water.

Method and Materials:
A sealed-water calorimeter of the Domen design was used in a ^{60}Co beam delivering approximately 15 mG/s. Bridge excitation and voltage measurements were performed with a lock-in amplifier, using a 100 Hz, 1 Vrms sine wave as a reference signal. Square-wave modulation of the radiation beam, achieved by controlling the source shutter, was conducted for shutter periods ranging from 60s to 3600s. For each shutter-period setting, measurements of the bridge imbalance (voltage) waveform were collected at a sample rate of 5 Hz for several hours. The waveforms were then analyzed using both time-domain (midpoint extrapolation) and frequency-domain techniques. All measurements were done at room temperature.

Results:
Severe distortion in the time waveform is observed for periods above 240s, precluding accurate dose estimation by midpoint extrapolation, but correct absorbed dose estimates are nevertheless obtainable via Fourier analysis. At periods below 240s, time-domain analysis converges to the results of Fourier analysis, and both concur with the historical value transferred by an ionization chamber.

Conclusion:
Several standards labs have been able to eliminate convection artifacts by incorporating external refrigeration systems that keep the water temperature near 4^{o}C. However, this comes at considerable cost, makes the calorimeter bulky and difficult to transport, and does not address the problem of conduction artifacts. Our approach may offer a more portable, robust, and efficient system for direct dose measurements in variable environments.

Conflict of Interest (only if applicable):