AbstractID: 7639 Title: A Theoretical Study of Boussinesq Convection in a Water Phantom

Purpose: To model natural convection in measurements of absorbed dose from water calorimeters operated at room temperature and to evaluate the efficacy of digital filtering for removing its effects**.**

Method and Materials: Finite-element calculations were conducted to simulate the response of a water phantom at room temperature (295K) to internal heating similar to that produced by a typical, radiotherapy-level ^{60}Co beam. Phantom dimensions of 30cm depth and diameter and an internal heat source measuring 10cm x 10cm at 5 cm depth and exhibiting a ^{60}Co depth-dose profile were chosen (per TG-51). The internal heat source was given a square-wave time dependence to simulate conditions of repeated opening/closing of a shutter, and spatial distributions of both temperature and velocity were obtained as functions of time and (via FFT) frequency. Simulations were carried out both with and without buoyant forces specified, with shutter periods up to 1800 seconds, so that attenuation and phase distortion due to natural convection could be isolated.

Results: Natural convection was observed at all shutter periods studied, increasing in intensity with increasing shutter period. In the time domain, convection and conduction produce cooling effects that cause similar nonlinearities in measured temperature waveforms at smaller shutter periods, while at longer shutter periods, convection is marked by temporal oscillations. In the frequency domain, convection is readily identified in the temperature signals at all shutter periods by modulation products at even harmonics of the shutter fundamental frequency. This artifact is consistent with a perturbative treatment of the Boussinesq Navier-Stokes equations.

Conclusion: With the frequency-domain results, we believe we have found a unique experimental signature for natural convection in water calorimetry. The simple oscillatory behavior of the phenomenon suggests that its effects may be eliminated by means of digital filtering.

Conflict of Interest (only if applicable):