

AbstractID: 5418 Title: Transfer-function characterization of heat conduction in water calorimetry

Purpose: To elaborate a transfer-function approach to characterizing the response of water calorimeters to abbreviated exposures in radiation beams.

Method and Materials: Typical water calorimeters in use today derive from the original design of Domen, inferring absorbed dose from temperature measurements at a single point in a partially irradiated, extended volume. The success of the approach in deducing locally absorbed dose depends on heat transfer being “sufficiently” slow temporally and broad spatially compared to time- and space-scales of the measurement. In order to address these issues of “sufficiency” more quantitatively, we have undertaken an approach to the problem that assesses the impulse-response of the calorimeter to spatially and temporally localized radiation. The approach involves simple analytical models of heat conduction and finite-element methods that yield predictions of single-point temperature waveforms obtained from thermistors in a calorimeter. Output from the models is compared with experiment over wide variations in shutter period (30s-10,800s) and duty cycle (5%-50%).

Results: Our findings show that heat conduction due to typical dose inhomogeneities within water calorimeters induces systematic variations in estimated dose that traditional data-analysis techniques ignore. Moreover, these variations do not diminish at smaller duty cycle, suggesting that they are intrinsic to the exposure time of the experiment, and not to the use of periodic exposure techniques. Essential features of the measurements are reproduced by both finite-element simulations and a simple analytical model. An RC-circuit analogue derived from the latter suggests that conduction phenomena with a spatially masked beam proceed by a multiplicity of times scales, ranging from seconds to hours, which contribute significantly to systematic variations in estimated dose.

Conclusions: The variations of estimated absorbed dose described here suggest that a small systematic error (<1%) may affect existing standards measurements based on water calorimetry.