AbstractID: 11478 Title: Calculation of water equivalent thicknesses of materials of arbitrary densities, elemental compositions and thicknesses in proton radiotherapy

Purpose: To develop simple and general analytical formulas to calculate water equivalent thickness (WET) values with an accuracy of 1 mm for materials commonly used in proton radiotherapy. **Method and Materials:** Based on theoretical range-energy relationships, three formulas were derived to predict the WET of materials of arbitrary density, composition and thickness Lead, aluminum, polymethylmethacrylate, polystyrene, and lung-equivalent slabs, which represent materials with different densities, were placed in therapeutic proton fields. Alternative approaches were developed for targets that were 'radiologically thin' or 'thick'. We compared the WET values calculated by the three formulas to those of experimental measurements and iterative numerical calculations. We also compared the accuracy of approximations based on International Atomic Energy Agency (IAEA) report and stopping power ratios (SPR) with numerical calculations. **Results:** The differences between the values of WET calculated using the analytical formula and the measured data were less than 0.8 mm. Likewise, the WET values calculated using analytical formulas agreed well with those calculated numerically, while IAEA and SPR approximations only work well for thin targets. The comparisons revealed that simple analytical methods could be used to calculate WET values with small, known errors. **Conclusion:** The results of this study provide evidence that simple analytical formulas can be used to accurately calculate WET of various materials in proton fields of therapeutic energies. Therapeutic proton beams are commonly characterized by their water-equivalent ranges; therefore, the formulas developed in this study can be used for the convenient and accurate calculation of WET values for common clinical and research applications.