Electron Beam Calibration using a Depth-Dose Channel Ratio

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Electron beam calibration dosimetry traditionally requires the sequential use of depth-dose packs to tune the voltage for accuracy. Once the dose pack is irradiated and the dose established, the potentiometer is adjusted based on the results. While this is considered an acceptable industry practice, the process lacks an accurate performance curve based on computational dosimetry to serve as a reference. This would be particularly useful for quantifying absorbed dose in surface layers, where sterilization requires high confidence. The concept requires irradiating a dosimeter with and without an absorber layer above the dosimeter. The PENELOPE Monte Carlo code for radiation transport was used to calculate a channel ratio between the alanine dosimeter and stepped polyethylene absorber layers. 50 KeV increments ranging from 100 KeV to 300 Kev were examined for use as a reference curve during electron beam calibration. Once the combination of absorber thickness and beam energy were optimized to produce a peak distribution at specific increments, all 200 energy levels were simulated for reference curves. Sources of uncertainty were considered along with methods of reducing that uncertainty.

In addition, material thickness boundaries were explored. Using simulations at increasing layer thickness, the influence of an LDPE absorber layer, titanium window and air gap between the window and substrate were investigated to define realistic parameters for successful replication. Once established, variations in the thicknesses were run through radiation transport calculations and the F-statistic from a single factor analysis of variance was studied as a method of comparing the curve from a point on the new calibration curve. This comparison chooses the most closely matched radiation dose based on similar behavior. Once established, a comparator program was written to account for those small variations in material thickness. This program was written in python code.

As a result, the air gap should be under 2 cm, and the titanium window thickness must be a 10 um window for the concept to work. Any variation within the air gap of 2 cm, and LDPE thickness of +/- 10% is allowable. The importance of this method in electron beam calibration can be attributed to accuracy at the low-energy range, providing an enhancement in dose control.

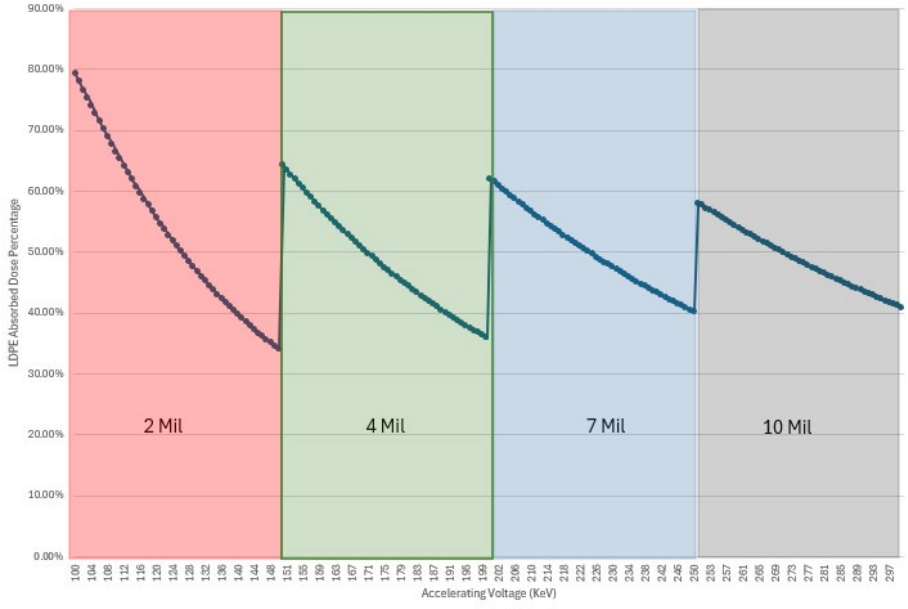

Figure 1. 100-300 KeV Electron Beam Calibration Curve Using Depth Dose Channel Ratio