Abstract

Energy dependent dosimeters used in clinics and research laboratories require calibration in a known radiation field of a closely matching energy to the radiation the dosimeters will be measuring. Primary standards labs, such as NIST in the United States, and secondary standards labs, such as the UW ADCL, have standard x-ray beams and radioactive sources like Cs-137 and Co-60 for the purpose of calibration. The standard x-ray beams established at NIST and matched at the UW ADCL have a maximum energy of 250 keV and the next energy step is Cs-137 which emits gamma rays with energy of 662 keV. There lies a gap in standard photon radiation between 250 keV and 662 keV which is an energy range that is increasingly becoming more commonly used. These applications in the higher energy range include radiobiology cabinet and conformal irradiators, Ir-192 brachytherapy sources, and the replacement of Cs-137 research irradiators with higher energy x-ray irradiators. The main goal of this work was to investigate the establishment of standard x-ray beams in this energy range and the development of the absolute dosimeters needed to establish them.

Outside of primary standards laboratories, a free-air chamber that could measure x-rays in the medium-energy range did not exist prior to this work. The free-air chamber designed, built and benchmarked for this work can measure photons up to 320 keV. To measure higher energy x-rays, known-volume ionization chambers were also established. These chambers typically require ultra-precise machining methods, but this work showed the possibility of establishing these chambers with μCT imaging and electric field modeling of commercial ionization chambers.

An industrial x-ray tube capable of producing x-rays up to 500 keV was used to establish the x-ray beams created in this work. The x-ray tube was modeled in the EGSnrc Monte Carlo code to investigate how filtration affected the x-ray spectra. This allowed for

the x-ray beams created to match two common radiobiology irradiators to be matched in spectra as well as maximum energy and half-value layer. High density filters were investigated to establish x-ray beams with higher energies. A standard x-ray beam that lies in the 250-662 keV energy gap was established and possible filter combinations for the effective energy of an x-ray spectrum to be more closely aligned to the emitted gamma ray energies of Ir-192 brachytherapy sources.