Abstract

Most modern mammography units have an anode made of tungsten. However, there are not currently any tungsten-anode mammography calibration beams at primary or secondary standards laboratories in the US. Ion chambers may be calibrated in existing molybdenum-anode beams as their energy response is minimal at low x-ray energies, but this is not necessarily true for solid-state dosimeters which may display significant variations in response at photon energies below 50 keV. This project focused on creating and characterizing tungsten-anode mammography calibration beams that are matched in terms of half-value layer (HVL) with beams that are currently in development at the National Institute of Standards and Technology (NIST). The performance of two low-energy solid-state dosimeters, referred to as x-ray multimeters (XMMs), were evaluated in the tungsten-anode mammography calibration beams as well as existing calibration beams.

Preliminary HVL measurements were acquired using the same nominal filter materials and thicknesses as the beams at NIST. Monte Carlo (MC) simulations of the Comet MXR-320/26 x-ray tube were validated using the initial HVL measurements. Other MC simulations were then used to determine the filter materials and thicknesses that resulted in matched HVLs with the beams at NIST. At the same time, a CdTe spectrometer was used to measure endpoint tube potentials and complete fluence spectra for all beams. Distortions of measured spectra were modelled using MC techniques and a novel tool for data collection in EGSnrc. Measured spectra were corrected for these distortions, and more than half of all corrected spectra had air-kerma values within ±5% of simulated air-kerma values. Air-kerma rates (AKRs) for the calibration beams were measured using the Attix FAC and beam-specific correction factors that were calculated from weighted averages of monoenergetic correction factors and simulated beam spectra.

The two XMMs that were investigated in this project were the RTI Piranha and Radcal AGMS-DM+. Both devices were accurate within manufacturer tolerances for AKR and HVL measurements of the UW-MO, UW-M, and tungsten-anode mammography calibration beam series. However, tube potential measurement results often had deviations exceeding the expected uncertainty of the measurements. Changes in the XMMs' responses relative to reference standards were also evaluated over a period of 29 months. While statistically significant drifts in relative response were observed, the overall magnitude of the changes were within manufacturer tolerances. Finally, applying an additional calibration factor to the measured data did not result in a significant increase in measurement accuracy relative to the original data. The XMM performance information that was gathered and the tungsten-anode mammography calibration beams that were developed in this project will

have applications in future calibration protocols and procedures for mammographic dosimeters.