Effects of Calibration Spectra On Mammographic Exposure Measurement

John Coletti

There are currently no national institute of standards and technology (NIST) standard molybdenum anode x-ray beams to calibrate ionization chambers employed to measure exposure from mammographic imaging systems. The current beams employed for the calibration of such ionization chambers are tungsten anode/aluminum filtered orthovoltage beams. These tungsten beams are matched with respect to accelerating potential (kVp) and half-value layer (HVL) to the imaging beams. Historically this tungsten/aluminum combination was established for low-voltage x-ray therapy applications.

The effects on the accuracy of the measurement of mammographic exposure due to the differences in the energy spectra of the calibration and clinical imaging beams have been investigated. The clinical and calibration x-ray beams have been characterized to enable the calibration of ionization chambers for accurate mammographic exposure measurements. The beams were characterized with regard to kVp, first and second half-value layers and photon-energy spectra, measured with a region to enable absolute exposure measurements in the x-ray beams. This free-air chamber was compared directly against the Ritz 20-100 kV free-air chamber at the NIST on their low-energy tungsten x-ray range. Disagreement between the Ritz and Attix free-air chambers is less than 0.24%, well within the uncertainty expected for such an intercomparison.

A variety of typical ionization chambers were calibrated against the free-air chamber and the response of these chambers versus the beam parameters are presented. Results of this research show that all current mammographic ionization chambers measure exposure accurately to within 5% on clinical mammography units if the chambers have been calibrated using the current tungsten anode, aluminum filtered calibration beams at the appropriate HVL and kVp.

Measurements of HVL for the tungsten and molybdenum beams were performed with four of the ionization chambers to show the effect of chamber energy response on the accuracy of HVL measurement. Better accuracy in exposure measurements will result from calibrations performed on molybdenum anode calibration beams being established as a continuation of this research.