Volume determination of a commercially available ionization chamber

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Abstract: The purpose of this project is to quantify the volume of a commercial spherical ionization chamber using micro-CT imaging techniques. Two Exradin A3 ionization chambers were imaged using a Siemens miroCT/microPET hybrid scanner with 50 μm resolution. The images were analyzed in MATLAB to determine the ISO50 threshold of the wall surfaces. The ISO50 surface determination method is common in additive manufacturing quality assurance. Contours of the volumes of the chambers were then created with the wall thresholds in the Siemens Inveon Research Workplace imaging software. The collection volume of the spherical chamber differs from its physical volume due to a portion of the electric field terminating in the guard instead of the collecting electrode. The electric field was modeled in COMSOL Multiphysics to quantify this discrepancy. The volume of the electric field that terminates in the guard was subtracted from the physical volume. To account for magnification in the CT images, a magnification factor was calculated and applied. Through these imaging techniques it was determined that the chambers had volumes of 3.55 cm^3 and 3.40 cm^3 with an uncertainty of 1.80% at k=2. A validation of these volumes was done by comparing them to the volumes calculated by a Co-60 air kerma calibration. Known-volume chambers require correction factors for the walls, stopping powers, air attenuation, radiation yield and humidity. These correction factors were calculated with various EGSnrc user codes and NIST values. Verification that the known-volume chambers were measuring air kerma correctly was done by taking measurements of radioactive sources and standard x-ray beams and comparing them to calibrated, NIST-traceable ionization chamber measurements. All the compared air kerma values were within the uncertainty of the volumes.

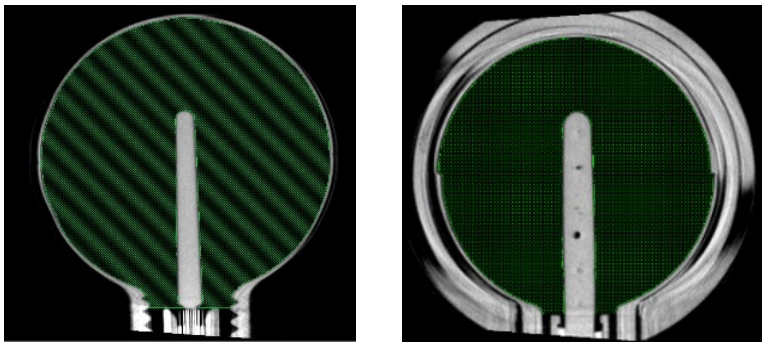

Figure 1: MicroCT images of the two Exradin A3 ionization chambers used for this project with their volume contours shown in green

Table 1: Comparisons of the two known-volume chambers to calibrated, NIST-traceable ion chamber measurements

M250 x-ray beam	Chamber 1 S/N: XR191680	Chamber 2 S/N: 256	A3 S/N: XR022483
Air kerma rate [mGy/s]	1.642	1.644	1.634
Percent difference from A3	**0.50%**	**0.63%**	--
Cs-137			A12 S/N: XA060332
Air kerma rate [mGy/s]	0.1732	0.1733	0.1732
Percent difference from A12	**0.005%**	**0.026%**	--
Co-60			A12 S/N: XA060332
Air kerma rate [mGy/s]	16.79	16.76	16.83
Percent difference from A12	**0.23%**	**0.43%**	--