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Update on NIST Intravascular Brachytherapy Standards and Calibrations

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NIST continues in its active program of intravascular brachytherapy measurements to serve the still-important application of beta-emitting sources in the inhibition of restenosis following balloon angioplasty by catheter-based radiation sources.

Techniques for source calibration and uniformity characterization have been developed employing a variety of measurement systems. A reference value of the absorbed-dose rate to water at a 2 mm depth in water-equivalent plastic is determined with the NIST medical extrapolation chamber equipped with a 1 mm diameter collecting electrode. Calibrated radiochromic-dye film, read out with high-resolution scanning densitometry, is used both to confirm the extrapolation chamber measurements and to provide information on the spatial distribution of absorbed-dose rate around the source. Additional confirmatory measurements are preformed on each source with calibrated well-ionization chambers and a calibrated scintillator system.

The NIST primary standard for beta-particle brachytherapy sources rely on extrapolation-chamber measurements, but uncertainties are unacceptably high (> 10% at 2σ), mainly because of curvature of the current vs. air-gap function, which leads to uncertainty in the measured absorbed-dose rate. Recent calculations have shown that this curvature can largely be removed through the application of a divergence correction to account for ionization losses at finite air gaps caused by the geometry of the source and extrapolation chamber. The divergence corrections were calculated using various Monte Carlo codes, although most of the calculations used to construct the correction are being done with EGSnrc Version 3. Air gaps between 0.01 mm and 0.5 mm were modeled, as well as three collecting electrode materials: carbon, water, and D400 conducting plastic. Collecting-electrode diameters between 1 mm and 8 mm were modeled, and for each of these collecting electrode/air gap combinations three ^{90}Sr/Y beta particle source geometries were modeled: a 1 cm diameter ophthalmic applicator, and 0.56 mm and 2.3 mm diameter seeds placed at a depth of 2 mm in water. The divergence corrections calculated by Monte Carlo methods are being compared to those predicted by a simple analytical Straight-Path Model. The corrections are applied to measurements, and the degree to which the reduction of the curvature in the current vs. air-gap function is being assessed. The use of the new divergence corrections should result in a significant

(approximately a factor two) reduction in the NIST uncertainty in absorbed0dose calibrations of beta brachytherapy sources.

In conjunction with these new correction factors, a new small-area collecting electrode has been fabricated from D400 conducting plastic using methods developed at NIST in the 1970s. The new electrode has a considerably narrower insulating ring (0.07 mm versus 0.3 mm) compared to the carbon electrode used up until now. Investigations with this new collecting electrode are on-going.

It is strongly suggested that an intercomparison of beta-particle brachytherapy dosimetry be undertaken. NIST has obtained a reference ^{90}Sr/Y line source imbedded near the surface of an Al block, which should be suitable as a test artifact for this comparison.