

Update on NIST Prostate-Seed Brachytherapy Standards and Calibrations

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The NIST continues in its active program of brachytherapy source dosimetry measurements. The treatment of prostate cancer by low-energy x-ray-emitting seed implants, and the demand for primary calibration and characterization of such sources has continued unabated for the past eight years.

The primary air-kerma-strength standard for radioactive seeds used in prostate brachytherapy is maintained at the NIST using the Wide-Angle Free-Air Chamber (WAFAC). Thirty-three seed designs from eighteen manufacturers have been calibrated and characterized at the NIST since the WAFAC standard was introduced in 1999 (see Table 1 for current sources). Seed manufacturers periodically send batches of three to five seeds to the NIST for calibration. These seeds are then forwarded to several Accredited Dosimetry Calibration Laboratories (ADCLs) to establish and subsequently maintain the secondary standard at these laboratories for use in calibrating clinical chambers. The NIST measurement program includes measures to ensure that seeds submitted for WAFAC calibration are consistent and representative of that particular seed design so that associated errors will not be propagated down the traceability chain to the ADCLs, seed manufacturers, and therapy clinics. To address this issue, several additional measurements are made to further characterize a seed beyond the initial air-kerma strength calibration. The calibration coefficients of three well-ionization chambers (two commercial models and one designed and built at the NIST) are determined for each seed, and compared to past results to confirm consistency of well-chamber-to-WAFAC relative response. Well-chamber-response-to air-kerma-strength-ratio histories are kept for all seed models, and the NIST data is compared to well-chamber measurement results from the ADCLs. Stability of the WAFAC is verified by periodic measurements of instrument response to an ^{241}Am source.

For at least one seed from each batch, the photon spectrum emergent in the plane bisecting the seed axis is measured using a collimated high-purity germanium (HPGe) detector. The pulse-height distribution is converted to the absolute energy distribution of fluence rate emerging from the seed, which is then used to calculate air-kerma strength. This completely independent determination is compared with WAFAC results. Seed anisotropy is characterized by three additional measurements, including relative WAFAC measurements at 45 degree intervals about the long axis of the seed, x-ray spectra

measured with the seed positioned at 90 degree intervals about an axis perpendicular to the mid-point of the long axis of the seed, and radiochromic film measurements in contact-exposure geometry. Variations in the relative response of the WAFAC and well-ionization chambers have been attributed to a combination of differences in measurement geometry, fluorescence x-ray emission from non-radioactive seed components, and anisotropy of x-ray emission and self-absorption (attenuation) effects due to internal seed geometry. Seed-characterization measurements assist in the identification of aberrantly produced seeds that should be eliminated from the calibration process. Such complete characterization of a seed is necessary for quality assurance of WAFAC measurements, and to maintain accuracy in the transfer of standards to the ADCLs, seed manufacturers, and therapy clinics.

Table 1. Low-energy photon-emitting brachytherapy sources with NIST calibrations.

<u>Isotope</u>	<u>Manufacturer</u>	<u>Distributor</u>	<u>Seed Model</u>
^{125}I	North American Scientific	North American Sci.	Prospera I-125 (MED3631-A/M)
^{125}I	International Brachytherapy	IBt	InterSource 125 (1251L)
^{125}I	Bebig	Bebig	IsoSeed I-125 (I25.S06)
^{125}I	Best Medical International	Best Medical	Best I-125 (2301)
^{125}I	Implant Sciences	Implant Sciences	I-Plant (3500)
^{125}I	Bard Brachytherapy	Bard Brachytherapy	BrachySource (STM1251)
^{125}I	Theragenics Corporation	Theragenics	I-Seed I-125 (I25.S06)
^{125}I on Ag	GE Healthcare	GE Healthcare	OncoSeed (6711)
^{125}I on Ag	GE Healthcare	GE Healthcare	EchoSeed (6733)
^{125}I on Ag	Mills Biopharmaceuticals	Mentor	ProstaSeed (125SL, 125SH)
^{125}I on Ag	IsoAid, LLC	IsoAid	Advantage I-125 (IAI-125A)
^{125}I on Ag	Isotron	Nucletron	selectSeed I-125 (130.002)
^{103}Pd	Theragenics Corporation	Theragenics	TheraSeed (200)
^{103}Pd	North American Scientific	North American Sci.	Prospera Pd-103 (MED3633)
^{103}Pd	International Brachytherapy	IBt	OptiSeed 103 (1032P)
^{103}Pd	Best Medical International	Best Medical	Best Pd-103 (2335)
^{103}Pd	RadioMed Corporation	RadioMed	Genetra
^{103}Pd	IsoAid, LLC	IsoAid	Advantage Pd-103 (IAPd-103A)
^{131}Cs	IsoRay Inc.	IsoRay	CS-1