Clinical trials have shown the effectiveness of using radioactive brachytherapy sources in the prevention of coronary restenosis following an angioplasty procedure. With the clinical introduction of radioactive source trains for intravascular brachytherapy (IVBT) treatment to prevent restenosis, the question arises as to how the medical physicist can validate the calibration of these long source trains. The University of Wisconsin Accredited Dosimetry Calibration Laboratory (UW ADCL) is now calibrating well-type re-entrant ionization chambers for specific source models. The sources described in this investigation include the gamma-emitting $^{192}$Ir trains (consisting of seeds from Best Industries and marketed by Cordis) and beta-emitting $^{90}$Sr trains manufactured by Novoste Corporation. In both cases, a primary standard has been determined at the National Institute of Standards and Technology (NIST), and subsequently established at this ADCL.

Photon-emitting Sources

Photon-emitting sources are traceable to existing NIST air kerma strength standards, and the IVBT dosimetry is based upon the formalism described in the AAPM TG-60 report. The fundamental problem in IVBT calibration is that the sources are oriented in a line geometry at least 3 cm long. Therefore, existing clinical well chambers may not provide adequate calibration geometry due to axial limitations and fall off from the maximum response. The criteria established at the UW ADCL for well chamber acceptance is an axial response at least 6 cm long, with a +/- 2% standard deviation variance. An important criterion is to have this large “sweet spot” to avoid any corrections to the response due to collecting volume geometry limitations. There are some well chambers with long enough axial geometries, including new chambers being developed that allow the uniform measurement of pseudo line sources. To confirm the well chamber’s axial uniformity, a train of Best Industries $^{192}$Ir seeds at least as long as the clinical treatment geometry was obtained from the manufacturer. A seed train of 23 seeds, approximately 2.8 mCi each, separated by 1 cm spacers was sent to the UW ADCL. This train was used to check the calibration of various train lengths up to 23 seeds or 100 mm length versus a single seed calibration. For well chambers with a long sweet spot, the train calibration value agrees with the single seed chamber response to within 0.5%. Thus, a single seed calibration factor at the sweet spot location can be used to calibrate the entire source train. The clinical calibration of a photon-emitting seed train would be determined as follows:

$$S_k = Rdg \times N_{sk} \times C_e \times C_{tp}$$

Where $N_{sk}$ is the single-seed calibration factor provided by the ADCL, $C_e$ is the electrometer scale correction factor, and $C_{tp}$ is the air density correction factor (not necessary for sealed chambers). If the average strength per seed is needed, the value of the determined train air kerma strength should be divided by the number of seeds.

Trains up to 100 mm long can be measured with chambers having a large enough sweet spot without additional correction for the axial response fall off. Submitted well chambers that do not meet the UW ADCL axial uniformity criteria will not be calibrated for the IVBT geometry.

Beta-emitting Sources

Beta-emitting sources manufactured by Novoste Corporation are based on a NIST traceable absorbed dose to water at 2 mm calibration, and an independent contained activity calibration. The NIST absorbed dose to water determinations were made with a small volume extrapolation chamber. The uncertainty in the NIST dose to water calibration is +/- 15% at the 95% confidence level, which reflects the difficulty in the primary dose determination. The NIST activity determination was performed using a digestive assay technique, with an uncertainty of +/- 6% at the 95% confidence level.
Novoste Corporation has received FDA approval for the 30 mm and 40 mm trains, and is pursuing approval to market a 60 mm train. In addition to the Novoste $^{90}$Sr/$^{90}$Y source, Guidant expects to have FDA approval for a $^{32}$P source wire in the near future. The calibration techniques described herein appear to apply to these sources as well.

The question is frequently raised whether calibrations of well chambers should be based upon measurement of the beta particles themselves, or to create bremsstrahlung and measure the resultant x-rays. To answer this question, the UW ADCL performed measurements of NIST calibrated source trains with different well chamber inserts to determine axial and rotational variation in signal strength. It appears that filtering out the low energy beta particles with approximately 2 mm of acrylic and measuring the high energy beta particles provides the best precision for the greatest signal to noise value. The UW ADCL has received provisional accreditation to provide calibration of the Novoste 30 mm source train. A proficiency test has been performed with NIST to determine reproducibility of the 30 mm train, and the relative response of the 40 mm and 60 mm train calibration geometries. It appears that the 40 mm and 60 mm trains have an absorbed dose to water calibration factor that is a multiple of the 30 mm train as follows:

$$CF_{40} = 0.75 \times CF_{30} \quad \text{and} \quad CF_{60} = 0.50 \times CF_{30}$$

This interim scaling technique should produce results well within the measurement uncertainty until formal ADCL accreditation is approved for the 40 mm and 60 mm trains. The well chamber activity calibration factor should be independent of the source train length.

In conclusion, it appears that the UW ADCL component of uncertainty is approximately +/- 2% at the 95% confidence level ($k=2$). The contribution from the NIST primary calibration is +/- 6% for contained activity and +/- 15% for absorbed dose to water at 2 mm.

**Conclusion for Well Chamber Calibrations of Intravascular Brachytherapy Sources**

- The well chamber should have an axial sweet spot of at least 6 cm.
- Both gamma and beta sources can be used to calibrate well chambers that meet this criteria.
- A single NIST traceable $^{192}$Ir seed will be used for calibration of well chambers for the Cordis train, and a NIST traceable $^{90}$Sr/$^{90}$Y source train will be used to calibrate well chambers for the Novoste Beta-Cath system.

**Reference:**


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