Ph.D. Thesis Abstract for Kurt Stump

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Absolute Calorimetric Calibration of Low Energy Brachytherapy Sources

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In the past decade there has been a dramatic increase in the use of permanent radioactive source implants in the treatment of prostate cancer. A small radioactive source encapsulated in a titanium shell is used in this type of treatment. The radioisotopes used are generally ^{125}I or �^{0}�Pd. Both of these isotopes have relatively short half-lives, 59.4 days and 16.99 days, respectively, and have low-energy emissions and a low dose rate. These factors make these sources well suited for this application, but the calibration of these sources poses significant metrological challenges.

The current standard calibration technique involves the measurement of ionization in air to determine the source air-kerma strength. While this has proved to be an improvement over previous techniques, the method has been shown to be metrologically impure and may not be the ideal means of calbrating these sources. Calorimetric methods have long been viewed to be the most fundamental means of determining source strength for a radiation source. This is because calorimetry provides a direct measurement of source energy. However, due to the low energy and low power of the sources described above, current calorimetric methods are inadequate.

This thesis presents work oriented toward developing novel methods to provide direct and absolute measurements of source power for low-energy low dose rate brachytherapy sources. The method is the first use of an actively temperature-controlled radiation absorber using the electrical substitution method to determine total contained source power of these sources. The instrument described operates at cryogenic temperatures. The method employed provides a direct measurement of source power.

The work presented here is focused upon building a metrological foundation upon which to establish power-based calibrations of clinical-strength sources. To that end instrument performance has been assessed for these source strengths. The intent is to establish the limits of the current instrument to direct further work in this field. It has been found that for sources with powers above approximately 2μW the instrument is able to determine the source power in agreement to within less than 7% of what is expected based upon the current source strength standard. For lower power sources, the agreement is still within the uncertainty of the power measurement, but the calorimeter noise dominates. Thus, to provide absolute calibration of lower power sources additional measures must be taken. The conclusion of this thesis describes these measures and how they will improve the factors that limit the current instrument.

The results of the work presented in this thesis establish the methodology of active radiometric calorimetry for the absolute calibration of radioactive sources. The method is an improvement over previous techniques in that there is no reliance upon the thermal properties of the materials used or the heat flow pathways on the source measurements. The initial work presented here will help to shape future refinements of this technique to allow lower power sources to be calibrated with high precision and high accuracy.

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