Investigations of Well Chamber Altitude Corrections for a Cs-131 Low Energy Brachytherapy Source

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Objective: To determine the air kerma strength of their brachytherapy seeds prior to implant, a common practice in the clinic is to use an air communicating well-type ionization chamber. A number of correction factors are applied to the raw electrometer signal, including a correction to standard temperature and pressure [1]. This correction has been shown to overcorrect the signal for low energy photon sources at low ambient air pressures, such as those typically found at high altitudes [2]. An additional pressure correction (P_A) to account for this effect is applied after the standard temperature and pressure correction. This correction is calculated as:

$$P_A = k_1[P(\mathrm{mmHg})]^{k_2}$$

where the coefficients k_1 and k_2 are dependent on the source and model of chamber used. This work focused on the determination of the pressure correction for a new Cesium-131 (Cs-131) low energy photon brachytherapy source from Isoray Inc.

Materials and Methods: A purpose-built pressure chamber was constructed in the past which could achieve pressures ranging from 560mmHg to 800mmHg. Three Cs-131 sources were tested over this pressure range in increments of 20mmHg in three Standard Imaging (Middleton, WI) HDR1000+ and three Standard Imaging (Middleton, WI) IVB1000 air communicating well-type ionization chambers. Three runs of each source/chamber combination were completed. The standard temperature and pressure correction was applied to the average result at each pressure then normalized to the result at 760mmHg.

Results: Both the HDR and IVB results followed the expected form of a power fit with residuals below 0.8% for all points and R^2 values of 0.9973 and 0.9941, respectively (Figure 1). The correction coefficients obtained from the power fits are listed in Table 1.

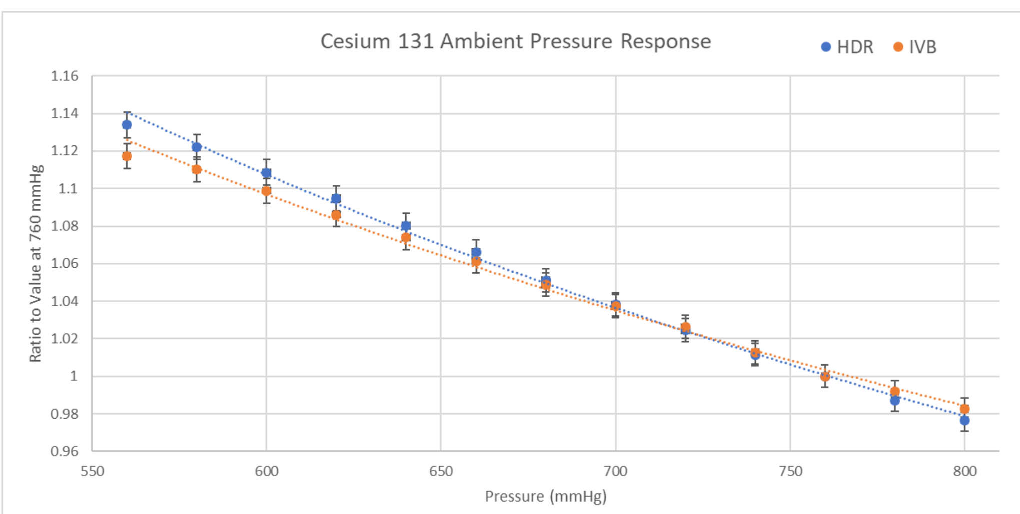

Figure 1: Measured response to a Cs-131 seed at varying pressures for the HDR 1000+ and IVB 1000 chambers. Error shown is the combined relative uncertainty with k=1.

Chamber	k_1	k_2
HDR 1000+	0.0580	0.429
IVB 1000	0.0825	0.376

Table 1: Table of coefficients to be used with the P_A correction factor as obtained from analytical curve fitting.

Conclusions and Significance: The correction factors for Cs-131 in the HDR1000+ and IVB 1000 well chambers were different from those determined for other low energy brachytherapy sources, such as Palladium-103 (Pd-103) and Iodine-125 (I-125). While both Pd-103 and I-125 had different correction factors, the factors for a given source measured in either an HDR1000+ or IVB1000 were the same. However, the responses of the two chambers with Cs-131 were different enough such that it necessitated a difference in correction factors. Thus, clinics must be careful to use the factors which correspond to the specific chamber model they use for air kerma strength calculations of Cs-131.

This difference was predicted through analysis of Monte Carlo models for the behavior of low energy photons in the chambers. Energy deposition in the outer active air region of the chambers contribute more to the overcorrection than deposition in the inner active air region and the higher the energy of the photons, the more energy is deposited into the outer region instead of the inner region [3]. Through a combination of larger active regions in the IVB 1000 and the higher energy of Cs-131 than Pd-103 or I-125, the differences between the HDR 1000+ and IVB 1000 are exacerbated to a point where their pressure responses no longer fall within error of each other. If new low energy photon brachytherapy sources are developed at an energy higher than the 30.4keV Cs-131 source, care must be taken to experimentally test both the HDR1000+ and IVB1000 for pressure response.

Relevance to CIRMS: As CIRMS has noted, brachytherapy is becoming a widely used option to treat prostate cancer [4]. This work demonstrates the importance of rigorously testing new products in a variety of situations as opposed to assuming they respond similarly to those previously used. While NIST has a calibration for this CS-131, the well chamber response was not measured. Due to the equipment and time needed to perform the experiments, Standards Labs are uniquely positioned to investigate new developments in the use of radiation much faster than many end users. For medical uses, this allows clinics to implement improvements in patient care sooner, fostering positive interactions between the Standards Labs and clinics. The first author intends to become a clinical medical physicist and currently works in a research laboratory which focuses on metrology. To complete this project, the first author learned how to correctly measure low dose rate brachytherapy sources and the importance of properly applying the necessary correction factors. These are skills that the author will take into their clinical work and share with future colleagues.

References:

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