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

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INTRODUCTION

In brachytherapy, source strength determinations are usually completed using a well-type ionization chamber where the raw reading is multiplied by multiple correction factors, as listed in TG-51, to give the true strength[1].

$$M = P_{ion} P_{TP} P_{elec} P_{pol} M_{raw}$$

However, for low energy photon sources measured in high-altitude, low ambient air pressure, environments, the P_{TP} correction for temperature and pressure overcorrects, leading to a potential under dosing of the patient as the sources are weaker than believed for dose calculation purposes.

To account for this effect, an additional correction factor is needed[2]

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

Where k_1 and k_2 are constants unique to the well chamber model and brachytherapy source being tested.

While numerous sets of the necessary constants have been determined for different sources, a Cesium 131 low energy brachytherapy source has been developed by Isoray Inc. which prior to this work did not have listed constants.

AIM

To determine the correction constants necessary to correct for altitude effects on ambient air pressure when determining the air kerma strength of Cs-131 low energy photon brachytherapy seeds.

METHOD

- A purpose-built pressure chamber was constructed which could achieve pressures from 560 mmHg to 800 mmHg.
- Three CS-1 Revision 2 Cs-131 sources from different lots were tested over this pressure range in 20 mmHg increments in three HDR1000 Plus and three IVB1000 air communicating well-type ionization chambers, both from Standard Imaging.
- Three measurements of each source/chamber combination were completed.
- The standard temperature and pressure correction was applied to the average result at each pressure and normalized to the result at 760 mmHg.
- A Monte Carlo model was also built in MCNP6 and both chambers were simulated to confirm the experimentally derived factors.

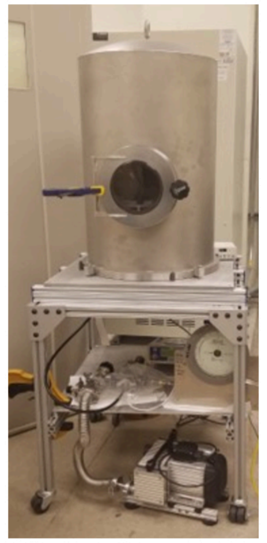

Figure 1: Pressure vessel with attached vacuum pump. Vessel was built in the past for similar measurements of other sources.

RESULTS

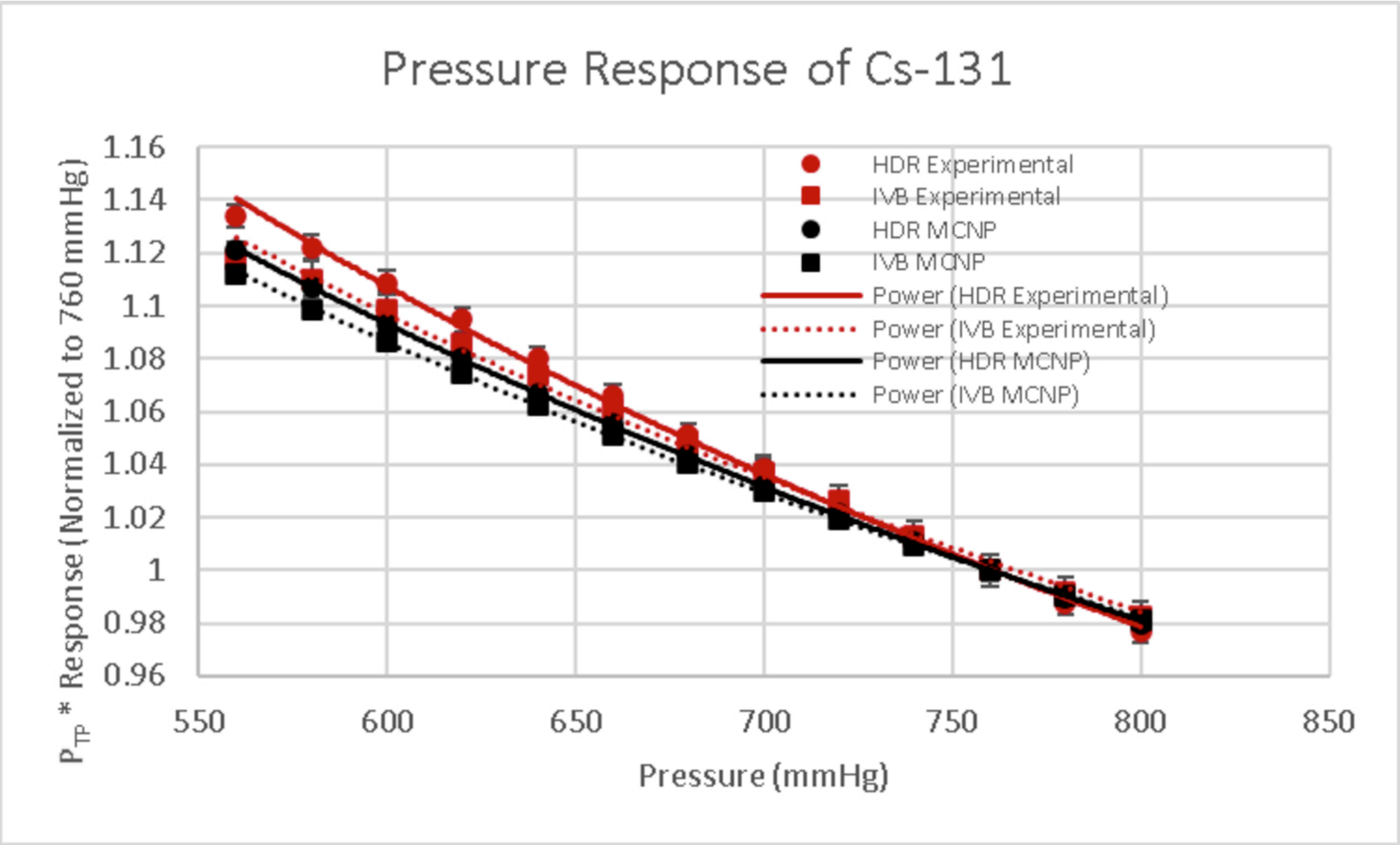

Figure 2: Average pressure response of Cs-131 in the HDR1000 Plus and IVB1000 well chambers. Error bars on the experimental data represent the k=1 uncertainty. Trendlines for curve fitting are power fits, consistent with the fitting done for sources in the past. The MCNP data being slightly lower than the experimental data is expected and agrees with the difference between measured and calculated pressure response from other authors[3].

Chamber	k_1	k_2	Uncertainty
HDR1000 Plus	0.0580	0.429	0.4%
IVB1000	0.0825	0.376	0.6%

Table 1: Constants to be used with the P_A correction factor as obtained from analytical curve fitting for Cs-131 sources. Uncertainties provided are combined relative uncertainties with k=1.

CONCLUSIONS

- As expected, the constants for the additional correction factor for Cs-131 are different from other low energy brachytherapy sources.
- However, unlike other sources, the factors are different for HDR1000 Plus and IVB1000 chambers, caused by the comparatively higher average energy of Cs-131.
- When testing the air kerma strength of their Cs-131 sources, clinics must take care to use the appropriate set of constants for their chamber.

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REFERENCES

[1] Almond *et al.* Med. Phys. **26**(9) 1847-1870 (1999)
[2] Griffin *et al.* Med. Phys. **32**(3) 700-709 (2005)
[3] Bohm *et al.* Med. Phys. **32**(4) 1103-1114 (2005)

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