SUBJECT: HDR 1000, HDR 1000 Plus and IVB 1000 Well Chamber Response as a Function of Pressure

The following information is provided as a service to our users and customers:

Over the years, Standard Imaging has received a few inquiries from customers in higher altitude environments (over 4500 feet above sea level) regarding the response of its HDR 1000, HDR 1000 Plus and IVB 1000 Well Chambers. These focused on differences in well chamber response when used with low-energy photon emitting brachytherapy sources, such as Pd-103 and I-125. None of the inquiries pertained to use with high-energy photon emitting brachytherapy sources, such as Cs-137 and Ir-192, or beta emitting brachytherapy sources, such as Sr-90 and P-32.

As a result of these inquiries, Standard Imaging helped support a study on well chamber response as a function of pressure. The following paragraphs provide a useful summary of the study findings. Further details from this study conducted by the University of Wisconsin, Accredited Dosimetry Calibration Laboratory (UW-ADCL) can be found in the references cited at the end of this document.

Calibration factors provided by the UW-ADCL are corrected to standard temperature and pressure (STP: 22 °C and 760 Torr), and must be applied to clinical measurements to obtain the correct air kerma strength for the source. As with many other products, including other ionization chambers, Standard Imaging well chambers may be affected by significant changes in pressure. With Standard Imaging well chambers, this effect is linked to their vented design, which was incorporated to eliminate the risk of leak-related response problems associated with pressurized well chambers.

In anticipation of potential response issues, the User Manuals for these well chambers contained applicable information and instructions in three different sections. The section entitled Constancy Check described the recommended methods for monitoring response constancy and stability. The Overview section of the manual provides that “sources must be calibrated when placed in use and should be checked periodically during use.” Lastly, the Procedures section provides “analyze the data taking into account the average readings, system leakage, temperature/pressure corrections, calibration factors and any other appropriate corrections to be made”.

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The study demonstrated that for some sources significant decreases in ambient pressure could predictably affect well chamber response.

- With low-energy photon emitting brachytherapy sources, such as Pd-103 and I-125, predictable and linear decreases in response are seen. This difference in response becomes more significant and exceeds the calibration uncertainty with pressure decreases seen at higher altitudes.
- With high-energy photon emitting brachytherapy sources, such as Cs-137 and Ir-192, and beta emitting brachytherapy sources, such as Sr-90 and P-32, there is little to no effect with pressure decreases as seen at higher altitudes.

Because of this predictability, it has been determined that the response differences for low-energy photon emitters \(^1\) may be corrected by the use of an additional correction factor, beyond that provided on the calibration certificate from the ADCL and after normal application of the \(C_{TP}\) correction factor. The equation incorporating this additional correction factor related to pressure (altitude related air density) is provided below, as are the required constants. No additional correction factor is required for high-energy photon emitters and beta emitters.

\[
M_{corr} = M_{raw} \times \left[ \frac{273.15 + T(\degree C)}{295.15} \times \frac{760}{P(\text{Torr})} \right] \times \left[ k_1 \times [P(\text{Torr})]^{k_2} \right]
\]

<table>
<thead>
<tr>
<th>Low-Energy Photon Emitting Brachytherapy Source</th>
<th>(k_1)</th>
<th>(k_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pd-103</td>
<td>0.0241</td>
<td>0.562</td>
</tr>
<tr>
<td>I-125 (without silver)</td>
<td>0.0490</td>
<td>0.455</td>
</tr>
<tr>
<td>I-125 (with silver)</td>
<td>0.0573</td>
<td>0.431</td>
</tr>
</tbody>
</table>
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The cause of this low energy pressure effect involves a combination of the range of the electrons being on the order of the size of the air cavity itself and the consequences of backscatter from the aluminum walls of the chamber. This is further explained in Reference 2 below. The chamber volumes for energies this low are medium sized cavities. For SI chambers, the distance across the inner and outer active region of the well chambers is on the order of the range of electrons generated by the low-energy photons emitted. Thus a large fraction of the generated electrons will stop in the active region. The apparent over response of the well chamber is caused by these terminating electrons because the \( C_{TP} \) correction should not be applied to electrons that stop in the active region. This is a simplified explanation for a complex phenomenon. For a more detailed explanation see the Medical Physics papers referenced below.

Standard Imaging therefore recommends the following:

- Compare the rated or labeled activity of the source with the air kerma strength measurements obtained with the well chamber during recommended periodic checks.
- When using a Standard Imaging well chamber with low-energy photon emitting brachytherapy sources at pressures significantly below 760 Torr, incorporate the additional correction factor related to pressure response differences, after normal application of the \( C_{TP} \) correction factor.
- Continue to follow the instructions provided in the well chamber User Manuals.

Standard Imaging has updated the User Manuals for the HDR 1000 Plus and the IVB 1000 Well Chambers to incorporate this additional information. Copies of updated User Manuals are available on the Standard Imaging website or may be obtained, free of charge, from Standard Imaging.

If there are any questions or comments regarding this information, please contact Standard Imaging or your authorized dealer.
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References:
