Migration to new ampoule types for the NPL Secondary Standard Ionisation Chambers

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Introduction
The two NPL secondary standard ionisation chambers have been extensively calibrated and enable on-going provision of efficient activity standardisations. The resulting calibration factors are defined in a specific measurement matrix, comprising containment of aqueous sources in BS glass ampoules and dedicated holders.

As the pre-calibrated BS ampoules are being phased out, ISO ampoules have been identified as suitable replacements. Initial checks indicated the need to recalibrate both ionisation chambers particularly for low energy photon emitting radionuclides.

Characterisation checks have been performed to confirm the physical properties of the ISO ampoules and to quantify their effect on both NPL systems. A long term recalibration schedule has been devised and several ISO calibration factors determined.

Measurement format
As the two NPL ionisation chambers (TP-MkiII and Venti67T) are of different design specifications, each system was checked individually.

The measurement matrix utilised was BS and ISO ampoules containing radioactive solution and placement in dedicated plastic holders for reproducible positioning in the ionisation chambers. A solid 106Am dip source was used for characterisation measurements.

Characterisation of ISO ampoules
The SCHOTT Type I neutral Fiolax closed top, clear glass, "One Point Cut" ampoules of type designated in section 3.2 of BS EN ISO 9187-2:2010 and of different nominal volumes were selected due to their good physical properties and their dimensional similarities to BS ampoules.

Measurements made in randomly selected ISO ampoules and after glass removal revealed negligible effects due to wall thickness variations. New holders were also redesigned to provide tailored fit and improved measurement reproducibility. Comparison of measurements before and after removal of various radionuclides for adsorption losses confirmed the good chemical resistance of the Type I glass.

The characterisation checks validated the long-established ± 0.1 % reproducibility of the NPL systems for the new measurement matrix.

Calibration method
Direct calibration transfer from the pre-calibrated 2 ml BS ampoule geometry was employed. For this, radioactive stock solution was accurately dispensed to ampoules then assayed in ionisation chambers. The current outputs per unit mass (pA MBq\(^{-1}\)) for ISO ampoules and the activity concentration (MBq g\(^{-1}\)) obtained from 2 ml BS ampoules produced calibration factors (pA MBq\(^{-1}\)) for individual radionuclides and NPL ionisation chambers, in a well-specified measurement format (i.e. ISO ampoule size, normalising mass and dedicated holder.)

The standardised samples were also used to calibrate the NPL high resolution gamma spectrometry systems.

Calibration Factors for ISO ampoules
Recalibration for 10 radionuclides resulting in 40 calibration factors for 2 ml and 5 ml ISO ampoules in both NPL ionisation chambers has been completed and several ISO calibration factors are presented here.

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>5 ml BS (pA/MBq)</th>
<th>Uncertainty (%)</th>
<th>BS 5 ml ISO (pA/MBq)</th>
<th>Uncertainty (%)</th>
<th>% Difference BS and ISO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Am</strong></td>
<td>1.2113 ± 0.24%</td>
<td>1.2216 ± 0.42%</td>
<td>7.86%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ce</strong></td>
<td>8.3980 ± 0.87%</td>
<td>8.4320 ± 0.71%</td>
<td>4.56%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Co</strong></td>
<td>7.9847 ± 0.86%</td>
<td>8.0116 ± 0.88%</td>
<td>0.83%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cr</strong></td>
<td>1.3030 ± 0.87%</td>
<td>1.3050 ± 0.70%</td>
<td>0.18%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ba</strong></td>
<td>16.788 ± 0.78%</td>
<td>16.916 ± 0.70%</td>
<td>0.74%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I</strong></td>
<td>16.020 ± 0.34%</td>
<td>16.200 ± 0.42%</td>
<td>1.13%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sr</strong></td>
<td>20.604 ± 0.67%</td>
<td>20.768 ± 0.71%</td>
<td>0.33%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ce</strong></td>
<td>22.481 ± 0.67%</td>
<td>22.486 ± 0.71%</td>
<td>0.19%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ba</strong></td>
<td>60.715 ± 0.67%</td>
<td>60.916 ± 0.71%</td>
<td>0.33%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sr</strong></td>
<td>58.197 ± 0.65%</td>
<td>58.289 ± 0.70%</td>
<td>0.15%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison of calibration factors revealed a significant increase in response induced by ISO ampoules of up to 7% for low energy photons and a greater container effect specifically for the TP-MkiII system and the 5 ml ISO ampoule size.

Volume Correction Factors
To correct for variable masses of solution, volume correction factors were also determined from 2 ml BS ampoules produced calibration factors for individual radionuclides and NPL ionisation chambers, in a well-specified measurement matrix, comprising containment of aqueous sources in BS glass ampoules and dedicated holders.

Recalibration of the NPL system will enable maintenance of the NPL’s essential standards of activity.

Conclusions
ISO ampoules have been identified as suitable replacement containers for activity assay the NPL ionisation chambers. The ISO calibration factors determined for several radionuclides of very low photon energies confirmed the need to recalibrate and will facilitate better planning of the overall level of recalibration.

Recalibration of the NPL system will enable maintenance of the NPL’s essential standards of activity.

References