# Complete uncertainty budget for the determination of the Pt emission rate for filter sample No. 4

## Model Equation:

*Calculation of analyte mass, expressed in pg Pt, by using following equation:*
$m_x = (M_x / (M_b * h_{xb})) * w_{yb} * (m_y * K_{my}) * ((R_y - R_{xy}) / (R_{xy} - R_x)) - m_{Bl}$

*Buoyancy correction factor*
$K_{my} = (1 - (\rho_a / \rho_w)) / (1 - (\rho_a / \rho_{ysol}));$

*Spike term*
$T1 = (M_x / (M_{194} * a_{x194})) * w_{yb};$

*Calculation of procedure blank in pg*
$m_{Bl1} = (T1 * (m_{yBl1} * K_{my}) * ((R_y - R_{Bl1}) / (R_{Bl1} - R_x)))*1000;$
$m_{Bl2} = (T1 * (m_{yBl2} * K_{my}) * ((R_y - R_{Bl2}) / (R_{Bl2} - R_x)))*1000;$
$m_{Bl3} = (T1 * (m_{yBl3} * K_{my}) * ((R_y - R_{Bl3}) / (R_{Bl3} - R_x)))*1000;$
$m_{Bl} = (0 + 0 + m_{Bl3}) / 3;$

*Calculation of filter blank in pg, procedure blank corrected*
$m_{FBW1} = (T1 * (m_{yFBW1} * K_{my}) * ((R_y - R_{FBW1}) / (R_{FBW1} - R_x)) * 1000) - (m_{Bl});$
$m_{FBW2} = (T1 * (m_{yFBW2} * K_{my}) * ((R_y - R_{FBW2}) / (R_{FBW2} - R_x)) * 1000) - (m_{Bl});$
$m_{FBW} = (m_{FBW1} + m_{FBW2}) / 2;$

*Calculation of Pt mass on filter 4 in pg, procedure blank corrected*
$m_{x4total} = (T1 * (m_{y4} * K_{my}) * ((R_y - R_{xy4}) / (R_{xy4} - R_x)) * 1000) - (m_{Bl});$

*Calculation of Pt mass on filter 4 in pg, corrected for filter blank*
$m_{x4} = m_{x4total} - m_{FBW};$

*Calculation of the Pt emission rate*
$CF_{ER\text{-}4} = m_{airsampler4} / (m_{airfilter4} * E_4);$
$ER_4 = CF_{ER\text{-}4} * CF * m_{x4};$

In this example the IDMS equation for the analyte quantification in the sample is displayed only, in order to keep it manageable. Therefore, the molar masses and the isotope abundance is treated as constants, because they cancel down, when combined with the IDMS equation for the spike characterization to form the so-called double IDMS equation. More details on this can be obtained from:

Vogl J, *Characterisation of reference materials by isotope dilution mass spectrometry*, J Anal At Spectrom 22 (2007) 475-492

Vogl J, Pritzkow W, *Isotope Dilution Mass Spectrometry – A primary method of measurement and its role for RM certification*, MAPAN – Journal of Metrology Society of India, 25 (2010) 135-164

## Uncertainty budget:

| Quantity | Value | Standard uncertainty | Unit | Type A/B | Description | Index |
|---|---|---|---|---|---|---|
| $R_x$ | 1.021993 | 0.000511 | 1 | A | Observed isotope ratio 195/194 in back-spike, used as natural isotope ratio | 0.0 % |
| $R_y$ | 0.0743205 | 0.0000372 | 1 | A | Observed isotope ratio 195/194 in spike | 0.0 % |
| $R_{Bl1}$ | 0.074195 | 0.000252 | 1 | A | Observed isotope ratio 195/194 in procedure blank 1 | 0.0 % |
| $R_{Bl2}$ | 0.074221 | 0.000200 | 1 | A | Observed isotope ratio 195/194 in procedure blank 2 | 0.0 % |
| $R_{Bl3}$ | 0.074965 | 0.000187 | 1 | A | Observed isotope ratio 195/194 in procedure blank 3 | 0.0 % |
| $R_{FBW1}$ | 0.076818 | 0.000353 | 1 | A | Observed isotope ratio 195/194 in filter blank 1 | 6.3 % |
| $R_{FBW2}$ | 0.076552 | 0.000260 | 1 | A | Observed isotope ratio 195/194 in filter blank 2 | 3.9 % |
| $R_{xy4}$ | 0.095712 | 0.000450 | 1 | A | Observed isotope ratio 195/194 in spiked filter 4 | 43.4 % |
| $w_{yb}$ | 10.56250 | 0.00160 | ng/g | B | Mass fraction of Pt-194 in spike solution | 0.0 % |
| $m_{yBl1}$ | 0.48760 | 0.000100 | g | B | Observed mass of spike used for procedure blank 1 | 0.0 % |
| $m_{yBl2}$ | 0.54663 | 0.000100 | g | B | Observed mass of spike used for procedure blank 2 | 0.0 % |
| $m_{yBl3}$ | 0.533590 | 0.000100 | g | B | Observed mass of spike used for procedure blank 3 | 0.0 % |
| $m_{yFBW1}$ | 0.512910 | 0.000100 | g | B | Observed mass of spike used for filter blank 1 | 0.0 % |
| $m_{yFBW2}$ | 0.550000 | 0.000100 | g | B | Observed mass of spike used for filter blank 2 | 0.0 % |
| $m_{y4}$ | 0.506520 | 0.000100 | g | B | Observed mass of spike used for filter 4 | 0.0 % |
| $\rho_a$ | 1.200 | 0.200 | kg/m$^3$ | B | Density of air | 0.0 % |
| $\rho_w$ | 8000.00 | 8.00 | kg/m$^3$ | B | Density of the weights of the balance | 0.0 % |
| $\rho_{ysol}$ | 1049.00 | 8.00 | kg/m$^3$ | B | Density of the spike solution | 0.0 % |
| $K_{my}$ | 1.000995 | 0.000166 | 1 | B | Factor for buoyancy correction applied for spike weighings | |
| $M_x$ | 195.084 | | g/mol | * | Molar mass of natural Pt (IUPAC) | |
| $M_{194}$ | 193.962663 | | g/mol | * | Molar mass of Pt-194 (IUPAC) | |
| $a_{x194}$ | 0.3286 | | g | * | Isotope abundance of natural Pt-194 (IUPAC) | |
| $m_{Bl1}$ | 0 | 0 | pg | ** | Mass of Pt in procedure blank 1 | |
| $m_{Bl1}$ | 0 | 0 | pg | ** | Mass of Pt in procedure blank 2 | |
| $m_{Bl3}$ | 11.75 | 3.49 | pg | B | Mass of Pt in procedure blank 3 | |
| $m_{airsampler4}$ | 4521.4 | 48.3 | kg | B | Mass of air through the particle transfer system (Costant Volume Sampler) | 8.4 % |
| $m_{airfilter4}$ | 1.2200 | 0.0130 | kg | B | Mass of air through the filter 4 | 8.4 % |
| $E_4$ | 30.990 | 0.620 | kWh | B | Consumed energy | 29.5 % |
| $CF$ | 0.001 | | ng/pg | | Conversion factor pg to ng, constant | |
| $ER_4$ | 40.14 | 1.48 | ng/kWh | B | Pt emission rate for filter 4 with its combined standard uncertainty | |
| $ER_4$ | 40.1 | 3.0 | ng/kWh | B | Pt emission rate for filter 4 with its expanded uncertainty ($k$ = 2) | |

* uncertainty is set to zero as parameter cancel down, when sample IDMS equation is combined with spike IDMS equation to form the double IDMS equation

** value and uncertainty is set to zero, because negative blank values were obtained