To be distributed to all the SIR participants

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Protocol on the use of the calibrated γ spectrometer of the BIPM for the measurement of impurities in ampoules submitted to the SIR.

Introduction

The presence of γ-ray emitting impurities in a solution (main activity A) submitted to the International Reference System (SIR) must be taken into account. The correction for the contribution of impurities to the ionization current, in use at the BIPM for some 20 years, is calculated from the relative impurity contents ($R_k = A_k / A$, where A_k is the activity of the impurity k at the reference date t_r) given by the NMI and corrected for decay, and from the efficiency of the chamber for the main radionuclide and for the impurities. These efficiencies are given by the inverse of the equivalent activities (Schrader, 1997; Reher et al., 1998). Therefore

$$C = 1 + \sum_k R_k \cdot \frac{\overline{A_e}}{A_{e,k}} \cdot D_k \quad , \qquad (1)$$

where A_e, $A_{e,k}$ are the equivalent activities of the main radionuclide and of the impurity k, respectively and D_k are decay corrections (see Michotte, 2000). When available, these equivalent activity values are taken as the mean or the median of the SIR results previously obtained for the corresponding nuclide. However, if no SIR data are available for the impurity and/or the main radionuclide, then $A_{e,k}$ and/or A_e are evaluated from the efficiency curve of the ionization chamber and the decay scheme of the nuclide (Rytz, 1983; Rytz and Müller, 1984; Schrader, 1997). The influence of an impurity may be amplified by more than an order of magnitude by the factor $A_e / A_{e,k}$. In consequence, even impurities presenting an R_k as small as 1×10^{-4} may have a non-negligible effect on the SIR result.

In order to improve the SIR data, the CCRI(II) agreed during its last meeting to use the calibrated Ge(Li) spectrometer of the BIPM (Michotte, 1999) to look for impurities either at the request of the national metrological institute (NMI) (to compare with its own measured value) or when SIR measurements show inconsistencies.

Protocol

- The NMI submits an ampoule of main activity A and impurity contents R_k. at the reference date
- The NMI may ask the BIPM to check the R_k values
- If the BIPM R_k values are different and produce a significant[1] change in the SIR result, the NMI is informed
- After discussion, the NMI R_k values may be changed to values agreed on the basis of scientific arguments.

[1] A change in the results is considered to be significant when the difference between the two SIR results is more than twice the standard uncertainty of this difference.

For short-lived radionuclides, the equivalent activity is often remeasured at different dates. If the resulting A_e values show a trend, this may be due to an inaccurate correction for impurities and/or an incorrect half life. In this case, the protocol is the following:

- The R_k values are checked using the BIPM spectrometer
- If the BIPM R_k values are different and reduce the trend observed, the NMI is informed. After discussion, the NMI R_k values may be changed to values agreed on this basis.
- If no agreement is reached between the NMI and the BIPM or if the cause of the trend is not identified and has a significant[1] effect on the SIR result, the submitted result should not be used in any determination of the Key Comparison Reference Value.

References

Michotte, C., 1999. *Efficiency calibration of the Ge(Li) detector of the BIPM for SIR-type ampoules.* Rapport BIPM-**99/3**, 15p.

Michotte, C., 2000. *Influence of radioactive impurities on SIR measurements.* ICRM'99 in Prague, Appl. Rad. Isot. **52** (3), pp 319-323.

Reher, D.F.G., Woods, M.J., Simpson, B.R.S., Ratel,G., 1998. *Portability of the calibration of SIR of BIPM to other ionization chambers for radioactivity measurements.* Appl. Rad. Isot. **49** (9-11), 1417-1419.

Rytz, A., 1983. *The international reference system for activity measurements of g-ray emitting nuclides*. Appl. Rad. Isot. **34** (8), 1047-1056.

Rytz, A. and Müller, J.W., 1984. *Système international de référence pour la mesure d'activité d'émetteurs de rayons g (SIR).* Procès-verbaux de la 73^e session du CIPM, **52**, ed. BIPM, Sèvres, France, pp. 76-77.

Schrader, H., 1997. *Activity Measurements with Ionization Chambers*. Monographie BIPM-**4**, Sèvres, France, pp. 40-47 and pp. 62-63.