Formulae to calculate the equivalent activity of a radionuclide A_e from the individual results of the participants in a CCRI(II) international comparison

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The equivalent activity is evaluated from measurements carried out in the SIR ionization chambers using the following expression

$$A_{e_i} = \frac{I_{Ra}}{I_i} \times A_i \times F_{Ra} \times e^{\lambda_{Ra}(t_{mes} - t_{Ra})} \times e^{\lambda_i (t_{mes} - t_0)}. \qquad (1)$$

where I_i is the ionization current produced by the sample i of total activity A_i at the reference date t_0,

I_{Ra} is the ionizationn current produced by the appropriate radium reference source at the reference date t_{Ra},

F_{Ra} is the ratio between the activity of the radium reference source used for the measurement and that of the most active reference source,

t_{mes} is the date of measurement,

λ_{Ra} and λ_i are the radioactive constants of the radium and of the radionuclide i.

At this stage two cases have now to be considered depending on how many ampoules from the comparison have been measured in the SIR ionization chamber.

Case 1.

All ampoules distributed have been measured in the SIR ionization chamber before their distribution to the participants. In this case for each ampoule the ratio $\frac{I_{Ra}}{I_i}$ is known. Each laboratory i receives an ampoule and determines the activity concentration of the solution C_i. Thus for this laboratory the total activity A_i is C_i x m_i where m_i is the mass of solution contained in the ampoule i.

The equivalent activity for the laboratory i is simply given by the expression

$$A_{e_i} = \frac{I_{Ra}}{I_i} \times C_i \times m_i \times F_{Ra} \times e^{\lambda_{Ra}(t_{mes} - t_{Ra})} \times e^{\lambda_i (t_{mes} - t_0)}. \qquad (2)$$

This case is similar to the submission of one ampoule by a laboratory to the SIR.

Case 2.

Sometimes it is not possible to measure the ampoules which will be dispatched to the participants, other than those sent to the BIPM. Hence two possibilities have to be considered.

a) Only one ampoule containing a mass of solution m is sent to the BIPM at the same time as the dispatch to the participants. The corresponding ionization current I_m is measured in the SIR ionization chamber.

At this stage it is assumed that the activity of an ampoule measured at the laboratory i will produce the same current as the ampoule of mass m measured at the BIPM. As a consequence the uncertainty has to be increased to take into account this assumption. Hence the equivalent activity for the laboratory i is simply given by the expression

$$A_{\mathrm{e_i}} = \frac{I_{\mathrm{Ra}}}{I_m} \times C_{\mathrm{i}} \times m_{\mathrm{i}} \times F_{\mathrm{Ra}} \times \mathrm{e}^{\lambda_{\mathrm{Ra}}(t_{\mathrm{mes}} - t_{\mathrm{Ra}})} \times \mathrm{e}^{\lambda_{\mathrm{i}}(t_{\mathrm{mes}} - t_0)}. \tag{3}$$

b) If several ampoules j of the batch prepared for the comparison are sent to the BIPM and measured in the SIR ionization chamber, the ionization current in (3) has to be replaced by the mean current

$\bar{I} = \frac{\sum_{k=1}^{\mathrm{j}} I_k}{\mathrm{j}}$ and the expression (3) becomes

$$A_{\mathrm{e_i}} = \frac{I_{\mathrm{Ra}}}{\bar{I}} \times C_{\mathrm{i}} \times m_{\mathrm{i}} \times F_{\mathrm{Ra}} \times \mathrm{e}^{\lambda_{\mathrm{Ra}}(t_{\mathrm{mes}} - t_{\mathrm{Ra}})} \times \mathrm{e}^{\lambda_{\mathrm{i}}(t_{\mathrm{mes}} - t_0)}. \tag{4}$$

The uncertainty in this case will be slightly smaller than when only one ampoule is measured.

Sunday, April 08, 2001