

Key comparisons CCEM-K4, EUROMET.EM-K4, APMP.EM-K4.1, SIM.EM-K4 and COOMET.EM-K4

MEASURAND : Capacitance

NOMINAL VALUE : 10 pF

FREQUENCY : ~ 1.6 kHz

Key comparison CCEM-K4

The key comparison reference value of CCEM-K4 is obtained from the weighted average of the results of the CCEM-K4 participants who derive their reference standard of capacitance by means of an independent realization of the farad from a calculable capacitor. It is chosen such that:

$x_R = x_0 \times (1 + m_R)$, with $x_R = 10$ pF exactly, that is, $m_R = 0$; the standard uncertainty of m_R is $u_R = 0.017 \times 10^{-6}$.

The degree of equivalence of each laboratory with respect to the reference value is given by a pair of terms: $D_i = (m'_i - m_R)$ and its expanded uncertainty ($k = 2$), U_i (see detailed calculation of U_i on page 17 of the CCEM-K4 Final Report), where m'_i is deduced from m_i by adding a constant factor chosen so that the reference value is a nominal 10 pF.

The degree of equivalence between two laboratories is given in the CCEM-K4 Final Report.

Linking EUROMET.EM-K4 to CCEM.EM-K4

The input data for establishing the link between EUROMET.EM-K4 and CCEM-K4 are taken from the two previous tables. In three cases, two EUROMET values are reported; the mean of the two values is used as the final result.

Seven laboratories (BIPM, LNE, NMIA, NIST, VSL, NPL and PTB) participated in both comparisons.

Each was asked if its results should be used for the link and, if so, to provide a 1σ estimate of the uncertainty, r_i , corresponding to the imperfect reproducibility of its measurements during the time elapsed between its measurements for the two comparisons. One of the participant (LNE) asked that its results not be used for the link.

The CCEM-K4 key comparison value and degrees of equivalence are unaltered by the linking procedure.

The linking procedure consists of evaluating the correction d to apply to the result $(m_{i-EUR} - m_{iR-EUR})$ of a laboratory participating in EUROMET.EM-K4 only, so that the corrected result represents the best estimate of what would have been the result of this laboratory had it actually participated in CCEM-K4.

The correction d is obtained as the weighted average of the difference of the results $[(m'_i - m_R) - (m_{i-EUR} - m_{iR-EUR})]$ obtained by the 6 linking laboratories in both comparisons.

Linking EUROMET.EM-K4 to CCEM.EM-K4 (Continued)

The weights are inversely proportional to the quantities $s_i^2 = t_i^2 + t_{i-EUR}^2 + 2r_i^2$, where t_i and t_{i-EUR} are the standard transfer uncertainties in the CCEM-K4 and EUROMET.EM-K4 key comparisons.

The result is: $d = 0.007 \times 10^{-6}$ with a standard uncertainty, $u_d = 0.0202 \times 10^{-6}$.

The degree of equivalence of each laboratory participant in EUROMET.EM-K4 with respect to the reference value is given by a pair of terms: $D_i = [(m_{i-EUR} - m_{R-EUR}) + d]$ and its expanded uncertainty ($k = 2$), U_i , based on the quadratic combination of u_R , u_d , t_{i-EUR} and $U_{i-EUR}/2$ (see page 2 and Table 2 of the Linkage Report).

The complete matrix of equivalence is built up as explained on pages 2 and 3 and in Table 3 of the Linkage Report.

Linking APMP.EM-K4.1 to CCEM-K4

The NMIA, NIM and VNIIM participated in both comparisons and were used as linking laboratories.

The linking procedure used to link the results of APMP.EM-K4.1 to those of CCEM-K4 is explained in paragraph 6.5 on page 17 of the APMP.EM-K4.1 Final Report, and is similar to that used to link EUROMET.EM-K4 to CCEM-K4.

The calculated linking correction $d = -0.004 \mu\text{F/F}$, with a standard uncertainty $u_d = 0.017 \mu\text{F/F}$.

The degree of equivalence of each laboratory participant in APMP.EM-K4.1 with respect to the reference value is given by a pair of terms D_i and its expanded uncertainty ($k = 2$), U_i . The computation of D_i and U_i can be found in paragraph 6.5.4 on page 19 of the APMP.EM-K4.1 Final Report.

The complete matrix of equivalence is built up as explained in paragraph 6.5.5 on page 20 of the APMP.EM-K4.1 Final Report.

Linking SIM.EM-K4 to CCEM-K4

The NIST and the NRC participated in both comparisons and were used as linking laboratories. The linking procedure used to link the results of SIM.EM-K4 to those of CCEM-K4 is explained in Appendix F on page 40 of the SIM.EM-K4 Final Report.

The degree of equivalence of each laboratory participant in SIM.EM-K4 with respect to the reference value is given by a pair of terms D_i and its expanded uncertainty ($k = 2$), U_i .

The pair-wise degrees of equivalence involving the SIM.EM-K4 participants are not computed.

Linking COOMET.EM-K4 to CCEM-K4

The PTB and VNIIM participated in both comparisons and were used as linking laboratories. The linking procedure used to link the results of COOMET.EM-K4 to those of CCEM-K4 is explained in Section 7.4 of the COOMET.EM-K4 Final Report.

The degree of equivalence of each laboratory participant in COOMET.EM-K4 with respect to the reference value is given by a pair of terms D_i and its expanded uncertainty ($k = 2$), U_i .

The pair-wise degrees of equivalence between participants in COOMET.EM-K4 are given on p. 12 of the COOMET.EM-K4 Final Report.