Key comparisons CCEM-K10 and EUROMET.EM-K10

Key comparison CCEM-K10

Measurand : Resistance **Pilot laboratory : PTB**
Nominal value : 100 Ω

x_i : result of measurement carried out by laboratory i, expressed as the relative deviation from the nominal value $R_0 = 100\ \Omega$, namely $R_i = R_0 \cdot (1 + x_i)$ where R_i is the resistance measured by laboratory i.
The x_i's are corrected to a nominal temperature of 23 °C and a nominal pressure of 1013.25 hPa.

U_{Labi} : expanded uncertainty (k = 2) of x_i

Lab *i* ⇩	Mean date	Four different transfer standards							
		Tegam No 2030397		Tinsley No 267 919		Tinsley No 262 767		Tinsley No 268 168	
		x_i / 10^{-9}	U_{Labi} / 10^{-9}	x_i / 10^{-9}	U_{Labi} / 10^{-9}	x_i / 10^{-9}	U_{Labi} / 10^{-9}	x_i / 10^{-9}	U_{Labi} / 10^{-9}
PTB	09/05/2001	-161.67	2.6	-5645.89	4.4	-3536.39	4.4	-1308	4.4
NIST	19/08/2001	-94.62	6.2	-5645.94	7.2	-3522.26	7.2	-1284.52	7.2
NRC	18/09/2001	-29.88	7.2	-5646.39	7	-3538.3	7	-1314.16	7
BIPM	16/10/2001	-26.88	4.4	-5636.89	4	-3537.06	4	-1284.8	4
PTB	25/11/2001	-49.38	2.6	-5640.37	4.4	-3517.55	4.4	-1292.49	4.4
MIKES	09/02/2002	3.93	11.4	-5531.44	11.4	-3494.17	11.4	-1283.73	11.4
NMIA	06/03/2002	0.04	64	-5530	62	-3520	62	-1279.99	62
PTB	28/04/2002	31.11	2.6	-5449.77	4.4	-3504.66	4.4	-1280.79	4.4
METAS	11/07/2002	64.65	5.8	-5417.4	5.8	-3525	5.8	-1290.6	5.8
PTB	20/09/2002	102.15	2.6	-5409.48	4.4	-3492.51	4.4	-1269.77	4.4
NMIJ	11/12/2002	132.93	15.6	-5388	12	-3485	12	-1288.01	12
BIPM	15/02/2003	211.27	14.2	-5386.1	16	-3487.19	16	-1251.06	16
PTB	18/03/2003	183.48	2.6	-5376.83	4.4	-3477.52	4.4	-1256.16	4.4
NIM	24/04/2003	221.7	1.4	-5390.42	1.4	-3474.19	1.4	-1259.28	1.4
PTB	02/08/2003	240.99	2.6	-5352.65	4.4	-3466.05	4.4	-1245.75	4.4

Key comparison CCEM-K10 (Continued)

Measurand : Resistance **Pilot laboratory : PTB**
Nominal value : 100 Ω

$D_{i\text{-comb}}$: combined mean of the travelling standards relative differences from a least-squares regression of the PTB values for each travelling standard

$U_{i\text{-comb}}$: expanded uncertainty (k = 2) of $D_{i\text{-comb}}$

$U_{i\text{-comb,T}}$: expanded uncertainty (k = 2) of $D_{i\text{-comb}}$, including an additional travel uncertainty estimated to 7 x 10^{-9}

(the calculation of the $D_{i\text{-comb}}$'s and the $U_{i\text{-comb}}$'s is described in detail in Section 6 on page 7 of the CCEM-K10 Final Report)

Lab *i* ⇩	$D_{i\text{-comb}}$ / 10^{-9}	$U_{i\text{-comb}}$ / 10^{-9}	$U_{i\text{-comb,T}}$ / 10^{-9}
PTB	0	4.56	8.4
NIST	6.99	11.63	13.6
NRC	-12.73	11.81	13.7
BIPM	-1.86	12.13	14
PTB	0	4.56	8.4
MIKES	12.01	16.23	17.7
NMIA	-5.7	61.65	62.1
PTB	0	4.56	8.4
METAS	-5.07	9.77	12
PTB	0	4.56	8.4
NMIJ	-2.42	16.88	18.3
BIPM	-1.39	17.89	19.2
PTB	0	4.56	8.4
NIM	4.92	10.11	12.3
PTB	0	4.56	8.4
PTB_{mean}	0	4.56	8.4

Key comparisons CCEM-K10 and EUROMET.EM-K10

Key comparison EUROMET.EM-K10

Measurand : Resistance **Pilot laboratory : PTB**
Nominal value : 100 Ω

Measurements were carried out using three sets of transfer standards in three loops in parallel. Corresponding results are reported in Tables 1 to 9 of Appendix A of the Final Report. Measurement dates are given in Section 2 of the Final Report.

The PTB is the only common laboratory to all loops and is used to link them (see Section 6 of the Final Report). Results are then expressed in terms of $\boldsymbol{D}_{i\text{-comb EUR}}$, the combined measurement of laboratory i relative to the PTB, and $\boldsymbol{U}_{i\text{-comb EUR}}$, the expanded uncertainty ($k = 2$) of $\boldsymbol{D}_{i\text{-comb EUR}}$ taking into account the travel uncertainty. These values are available in Table 16 of the Final Report.

The EUROMET reference value, $\boldsymbol{x}_{\text{R EUR}}$, and its associated expanded uncertainty ($k = 2$), $\boldsymbol{U}_{\text{R EUR}}$, are determined from the weighted mean of the $\boldsymbol{D}_{i\text{-comb EUR}}$ with the $\boldsymbol{U}_{i\text{-comb EUR}}$ used as weights. In this calculation only one value is considered for the pilot laboratory, and to exclude possible correlation, only those laboratories having their own representation of the ohm, based on the QHE, are taken into consideration.
$\boldsymbol{x}_{\text{R EUR}} = 4.0\ 10^{-9}$ **and** $\boldsymbol{U}_{\text{R EUR}} = 6.0\ 10^{-9}$

Degrees of equivalence inside the EUROMET key comparison are deduced using the appropriate equations (see Section 6.3 of the Final Report). They are given by a pair of terms:
$\boldsymbol{D}_{i\ \text{EUR}}$, the laboratory i offset relative to the EUROMET reference value, and the associated expanded uncertainty ($k = 2$), $\boldsymbol{U}_{i\ \text{EUR}}$.

Key comparison EUROMET.EM-K10 (Continued)

Measurand : Resistance **Pilot laboratory : PTB**

Nominal value : 100 Ω

Lab *i* ⇩	$D_{i\ EUR}$ / 10^{-9}	$U_{i\ EUR}$ / 10^{-9}
MIKES	5.31	17.1
SP	-15.74	29.3
JV	-10.45	15.4
DFM	6.91	378.4
VNIIM	22.16	63.7
MKEH	288.22	1738.6
GUM	-788.90	267.0
GUM*	-281.90	500.0
VMT	-70.43	143.4
LATMB	820.69	1821.4

Lab *i* ⇩	$D_{i\ EUR}$ / 10^{-9}	$U_{i\ EUR}$ / 10^{-9}
EIM*	-80.58	82.1
INRIM*	-28.31	78.2
CEM*	-22.30	87.6
IPQ	-239.13	253.5
METAS*	-45.22	71.8
MIRS/SIQ/Metrology	87.67	455.9
DMDM	904.71	1222.7
NPL	8.58	26.8
NSAI NML	198.65	411.8
LNE*	9.87	16.9
BIPM*	7.85	17.5

Lab *i* ⇩	$D_{i\ EUR}$ / 10^{-9}	$U_{i\ EUR}$ / 10^{-9}
SMD	34.56	99.9
CMI	7.22	101.4
UME	8.51	22.5
NMISA	165.64	600.8
VSL*	6.01	21.6
BEV	-63.93	329.2
PTB*	-4.04	9.7

***Italics*: acronyms of laboratories whose results are not used for the calculation of the EUROMET reference value.**

*** Denotes laboratories that claim an uncertainty smaller than the transport uncertainty. For these laboratories the result reflects the limited knowledge on the behavior of the travelling standards and not the capability of the laboratory.**

**** Denotes that the result was obtained by a repeated measurement in October 2006.**

Key comparisons CCEM-K10 and EUROMET.EM-K10

Key comparison CCEM-K10

Measurand : Resistance
Nominal value : 100 Ω

The key comparison reference value, x_R, is obtained from the weighted mean of the $D_{i\text{-comb}}$'s: $x_R = -0.14 \times 10^{-9}$.
Its associated uncertainty ($k = 2$) is $U_R = 4.57 \times 10^{-9}$ (see on page 8 of the CCEM-K10 Final Report).

The degree of equivalence of laboratory i with respect to the reference value is given by a pair of terms: the offset $D_i = D_{i\text{-comb}} - x_R$, and its expanded uncertainty ($k = 2$), $U_i = (U_{i\text{-comb,T}}^2 - U_R^2)^{1/2}$.

All uncertainties (except NMIA) are significantly greater than the laboratory's claims due to the added transport uncertainty of the resistors. So these results are limited by the transportability of the resistors and not by the capability of the participants. Therefore the degrees of equivalence between pairs of laboratories are not meaningful.

Linking key comparison EUROMET.EM-K10 to key comparison CCEM-K10

The linking laboratories are MIKES, METAS, BIPM and PTB.
The linkage process is explained in Section 6.4 of the EUROMET Final Report.

The degree of equivalence of laboratory i, participant in EUROMET.EM-K10 only, with respect to the CCEM-K10 key comparison reference value is given by a pair of terms: the offset $D_i = D_{i\ EUR} + x_{R\ EUR} - x_R$, and its expanded uncertainty ($k = 2$), $U_i = (U_{i\ EUR}^2 + U_{Link}^2)^{1/2}$, with $x_{R\ EUR} - x_R = 3.30\ 10^{-9}$ and $U_{Link} = 9.80\ 10^{-9}$.

Key comparisons CCEM-K10 and EUROMET.EM-K10

Measurand : Resistance

Nominal value : 100 Ω

Degrees of equivalence relative to the CCEM-K10 key comparison reference value

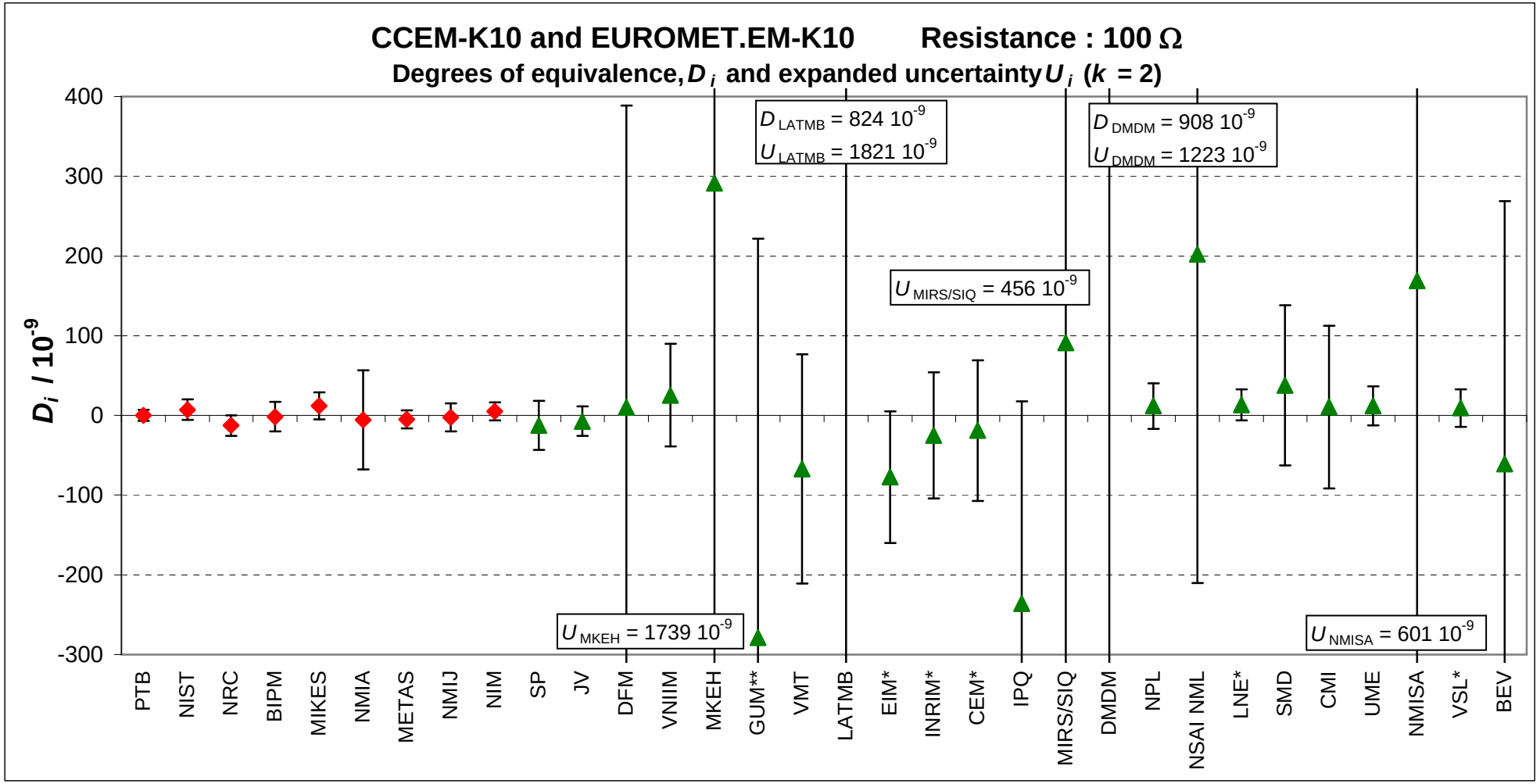
Lab *i* ⇩	D_i / 10^{-9}	U_i / 10^{-9}
PTB	**0.14**	7.0
NIST	**7.13**	12.8
NRC	**-12.59**	12.9
BIPM	**-1.48**	18.7
MIKES	**12.15**	17.1
NMIA	**-5.56**	61.9
METAS	**-4.93**	11.1
NMIJ	**-2.28**	17.7
NIM	**5.07**	11.4
SP	**-12.44**	30.9
JV	**-7.15**	18.3
DFM	**10.21**	378.5
VNIIM	**25.46**	64.5
MKEH	**291.52**	1738.6
GUM	**-785.60**	267.2
GUM**	**-278.60**	500.1
VMT	**-67.13**	143.7
LATMB	**823.99**	1821.4
EIM*	**-77.28**	82.7
INRIM*	**-25.01**	78.8
CEM*	**-19.00**	88.2
IPQ	**-235.83**	253.7
MIRS/SIQ/Metrology	**90.97**	456.0
DMDM	**908.01**	1222.7
NPL	**11.88**	28.5
NSAI NML	**201.95**	411.9
LNE*	**13.17**	19.5
SMD	**37.86**	100.4
CMI	**10.52**	101.9
UME	**11.81**	24.5
NMISA	**168.94**	600.9
VSL*	**9.31**	23.7
BEV	**-60.63**	329.4

* Denotes laboratories that claim an uncertainty smaller than the transport uncertainty.
For these laboratories the result reflects the limited knowledge on the behavior of the travelling standards and not the capability of the laboratory.

** Denotes that the result was obtained by a repeated measurement in October 2006.

In blue: linking laboratories

In green: participants in EUROMET.EM-K10 only



* Denotes laboratories that claim an uncertainty smaller than the transport uncertainty.
For these laboratories the result reflects the limited knowledge on the behavior of the travelling standards and not the capability of the laboratory.
** Denotes that the result was obtained by a repeated measurement in October 2006. Measurement of 2003 led to D_{GUM} = -785.60 10^{-9} and U_{GUM} = 267.2 10^{-9}

Red diamonds: participants in CCEM-K10 **Green triangles: participants in EUROMET.EM-K10 only**