CCEM-K8, EUROMET.EM-K8, CCEM-K8.1 and EUROMET.EM-K8.1

Key comparison CCEM-K8

MEASURAND: DC voltage ratio 1000 V / 10 V
NOMINAL VALUE: 100
TRAVELLING STANDARD: voltage divider Datron 4902S, s/n 20335
Pilot laboratory: IEN

$d_{0,i}$: fractional difference from nominal value of ratio $x_{0,i}$, measured by laboratory *i* and corrected to standard ambient conditions; it is given by: $x_{0,i} = 100 \times (1 + d_{0,i})$
The fractional differences $d_{0,IEN}$ assigned by IEN to the ratio are obtained by interpolation of the IEN measurement results to the measurement dates of the other laboratories.

$u_{G,i}$: global standard uncertainty of laboratory *i*

$\nu_{eff,i}$: number of effective degrees of freedom of laboratory *i*

Lab *i*	$d_{0,i}$ / 10^{-6}	$d_{0,IEN}$ / 10^{-6}	$\Delta_i = (d_{0,i} - d_{0,IEN})$ / 10^{-6}	$u_{G,i}$ / 10^{-6}	$\nu_{eff,i}$	Mean date of measurements
LCIE	-3.91	-4.28	0.37	0.18	94	1999-03-17
SP	-3.79	-3.72	-0.07	0.17	244	1999-06-04
NPL	-7.71	-3.72	-3.99	0.37	232	1999-08-20
CEM	-2.91	-3.72	0.81	0.28	24	1999-09-19
KRISS	-3.69	-3.72	0.03	0.09	24	1999-10-25
CSIRO-NML	-3.62	-3.71	0.09	0.16	28	2000-01-08
NIM	-3.97	-3.71	-0.26	0.18	56	2000-04-10
VNIIM	-4.12	-3.70	-0.41	0.10	30	2000-07-29
NIST	-3.69	-3.70	0.01	0.26	1215	2000-10-12
NRC	-3.53	-3.70	0.17	0.16	39	2000-11-02
MSL	-3.77	-3.69	-0.07	0.16	23	2001-01-06
CSIR-NML	-4.00	-3.69	-0.31	0.33	244	2001-03-01
NPLI	-2.97	-3.69	0.72	0.37	78	2001-04-07
NMIJ	-3.80	-3.69	-0.12	0.14	120	2001-06-01
IEN	-	-	0.00	0.12	621	-

Key comparison EUROMET.EM-K8

MEASURAND: DC voltage ratio 1000 V / 10 V
NOMINAL VALUE: 100
TRAVELLING STANDARD: voltage divider Datron 4902S, s/n 12422
Pilot laboratory: IEN

$d_{0,i\text{-EUR}}$: fractional difference from nominal value of ratio $x_{0,i\text{-EUR}}$, measured by laboratory i and corrected to standard ambient conditions; it is given by: $x_{0,i\text{-EUR}} = 100 \times (1 + d_{0,i\text{-EUR}})$
The fractional differences $d_{0,\text{IEN-EUR}}$ assigned by IEN to the ratio are obtained by interpolation of the IEN measurement results to the measurement dates of the other laboratories.

$\Delta_{i\text{-EUR}} = (d_{0,i\text{-EUR}} - d_{0,\text{IEN-EUR}})$

$u_{G,i\text{-EUR}}$: global standard uncertainty of laboratory i

$\nu_{\text{eff},i\text{-EUR}}$: number of effective degrees of freedom of laboratory i

Lab i	$d_{0,i\text{-EUR}}$ / 10^{-6}	$d_{0,\text{IEN-EUR}}$ / 10^{-6}	$\Delta_{i\text{-EUR}}$ / 10^{-6}	$u_{G,i\text{-EUR}}$ / 10^{-6}	$\nu_{\text{eff},i\text{-EUR}}$	Mean date of measurements
NPL	-2.58	-2.10	-0.48	0.23	283	1998-10-27
INETI	2.04	-2.13	4.17	2.90	> 1000	1998-11-25
CEM	-2.03	-2.23	0.20	0.40	21	1999-02-17
PTB	-2.30	-2.26	-0.04	0.18	36	1999-03-16
LCIE	-1.69	-2.31	0.62	0.16	104	1999-05-05
METAS	-2.41	-2.42	0.01	0.32	65	1999-08-11
CMI	-3.19	-2.46	-0.73	4.10	> 1000	1999-09-11
MIKES	-2.33	-2.51	0.18	0.24	491	1999-11-02
SP	-2.42	-2.54	0.13	0.17	837	1999-11-29
UME	-5.21	-2.65	-2.56	0.47	> 1000	2000-03-01
SMU	-3.51	-2.68	-0.83	1.20	> 1000	2000-03-30
NMi-VSL	-2.27	-2.72	0.44	2.62	150	2000-05-03
JV	-3.39	-3.07	-0.32	0.17	68	2000-09-17
SMD	-2.91	-3.18	0.27	0.47	> 1000	2000-10-20
MIRS/SIQ	-3.27	-3.39	0.11	0.33	> 1000	2000-12-16
BEV	-4.30	-4.15	-0.15	0.70	306	2001-10-17
OMH	-4.40	-4.14	-0.26	0.72	186	2001-11-15
EIM	-4.91	-4.12	-0.79	0.13	25	2001-12-23
IEN	-	-	0.00	0.13	81	-

Key comparison CCEM-K8.1

CCEM-K8.1 is a follow-up comparison of CCEM-K8

MEASURAND: DC voltage ratio 1000 V / 10 V
NOMINAL VALUE: 100
TRAVELLING STANDARD: voltage divider Datron 4902S, s/n 20335
Pilot laboratory: IEN

$d_{0,i\text{-K8.1}}$: fractional difference from nominal value of ratio $x_{0,i\text{-K8.1}}$, measured by laboratory *i* and corrected to standard ambient conditions; it is given by: $x_{0,i\text{-K8.1}} = 100 \times (1 + d_{0,i\text{-K8.1}})$
The fractional difference $d_{0,\text{IEN-K8.1}}$, assigned by IEN to the ratio, is obtained by interpolation of the IEN measurement results to the measurement date of the participant laboratory.

$\Delta_{i\text{-K8.1}} = (d_{0,i\text{-K8.1}} - d_{0,\text{IEN-K8.1}})$

$u_{G,i\text{-K8.1}}$: global standard uncertainty of laboratory *i*

$\nu_{\text{eff},i\text{-K8.1}}$: number of effective degrees of freedom of laboratory *i*

Lab *i*	$d_{0,i\text{-K8.1}}$ / 10^{-6}	$d_{0,\text{IEN-K8.1}}$ / 10^{-6}	$\Delta_{i\text{-K8.1}}$ / 10^{-6}	$u_{G,i\text{-K8.1}}$ / 10^{-6}	$\nu_{\text{eff},i\text{-K8.1}}$	Mean date of measurements
CEM	3.35	2.94	0.42	0.17	296	2002-11-25
IEN	-	-	0.00	0.12	590	-

Key comparison EUROMET.EM-K8.1

EUROMET.EM-K8.1 is a follow-up comparison of EUROMET.EM-K8

MEASURAND: DC voltage ratio 1000 V / 10 V
NOMINAL VALUE: 100
TRAVELLING STANDARD: voltage divider Datron 4902S, s/n 20335
Pilot laboratory: IEN

$d_{0,i\text{-EUR-K8.1}}$: fractional difference from nominal value of ratio $x_{0,i\text{-EUR-K8.1}}$, measured by laboratory *i* and corrected to standard ambient conditions; it is given by: $x_{0,i\text{-EUR-K8.1}} = 100 \times (1 + d_{0,i\text{-EUR-K8.1}})$
The fractional differences $d_{0,\text{IEN-EUR-K8.1}}$ assigned by IEN to the ratio are obtained by interpolation of the IEN measurement results to the measurement dates of the other laboratories.

$\Delta_{i\text{-EUR-K8.1}} = (d_{0,i\text{-EUR-K8.1}} - d_{0,\text{IEN-EUR-K8.1}})$

$u_{G,i\text{-EUR-K8.1}}$: global standard uncertainty of laboratory *i*

$\nu_{\text{eff},i\text{-EUR-K8.1}}$: number of effective degrees of freedom of laboratory *i*

Lab *i*	$d_{0,i\text{-EUR-K8.1}}$ / 10^{-6}	$d_{0,\text{IEN-EUR-K8.1}}$ / 10^{-6}	$\Delta_{i\text{-EUR-K8.1}}$ / 10^{-6}	$u_{G,i\text{-EUR-K8.1}}$ / 10^{-6}	$\nu_{\text{eff},i\text{-EUR-K8.1}}$	Mean date of measurements
SMU	-0.58	-1.27	0.69	1.20	inf.	10/11/2003
UME	-1.35	-1.31	-0.04	0.17	109	26/12/2003
NMi-VSL	-1.57	-1.37	-0.20	0.31	128	20/02/2004
IEN	-	-	0.00	0.12	524	-

CCEM-K8, EUROMET.EM-K8, CCEM-K8.1 and EUROMET.EM-K8.1

MEASURAND: DC voltage ratio 1000 V / 10 V **NOMINAL VALUE: 100**

Key comparison CCEM-K8

The key comparison reference value, Δ_R, is the arithmetic mean of the differences Δ_i, obtained from twelve participants. (Statistical tests indicate that there is a high probability that the result of each of the other three participants does not belong to the same statistical distribution as the other twelve). The mean relative deviation of the ratio from nominal is given by the sum $\Delta_R + d_{0,IEN}$. The standard uncertainty, $u(\Delta_R)$, associated with Δ_R is the standard deviation of the mean.

Δ_R = -0.048 10^{-6} with standard uncertainty of 0.062 10^{-6} and 11 degrees of freedom.

The degree of equivalence of each laboratory with respect to the reference value is given by a pair of terms: $D_i = (\Delta_i - \Delta_R)$, and the corresponding expanded uncertainty U_i, assessed for a level of confidence of 95%. For the 12 laboratories contributing to the definition of the reference value, the correlation with the reference value is taken into account in the computation of U_i.

Key comparison EUROMET.EM-K8

The reference value, $\Delta_{R\text{-}EUR}$, is the arithmetic mean of the differences $\Delta_{i\text{-}EUR}$, obtained from seventeen participants. (Statistical tests indicate that there is a high probability that the result of each of the two other participants does not belong to the same statistical distribution as the other seventeen). The mean relative deviation of the ratio from nominal is given by the sum $\Delta_{R\text{-}EUR} + d_{0,IEN\text{-}EUR}$. The standard uncertainty associated with $\Delta_{R\text{-}EUR}$ is the standard deviation of the mean.

$\Delta_{R\text{-}EUR}$ = -0.097 10^{-6} with standard uncertainty of 0.103 10^{-6} and 16 degrees of freedom.

The degree of equivalence of each laboratory with respect to the reference value is given by a pair of terms: $D_{i\text{-}EUR} = (\Delta_{i\text{-}EUR} - \Delta_{R\text{-}EUR})$, and the corresponding expanded uncertainty $U_{i\text{-}EUR}$, assessed for a level of confidence of 95%. For the 17 laboratories contributing to the definition of the reference value, the correlation with the reference value is taken into account in the computation of $U_{i\text{-}EUR}$.

Linking key comparison EUROMET.EM-K8 to CCEM-K8

In a measurement of voltage ratio, no national standard is involved. Therefore any participant in EUROMET.EM-K8 and CCEM-K8 comparisons can be considered equally able, in principle, to perform an unbiased measurement of the travelling standard. Since the number of participants in each comparison is significant and different methods of measurement were used, it is unlikely that the corresponding comparison reference values are affected by systematic errors. Therefore they are equivalent and the degrees of equivalence obtained from the EUROMET comparison are assumed to be the same as if the participants had taken part in the CCEM-K8 comparison;

$D_i = D_{i\text{-EUR}}$ and $U_i = U_{i\text{-EUR}}$ for the participants in EUROMET.EM-K8 comparison.

The linking document reports a verification of this assumption based on the results of the common participants in both comparisons.

Because voltage ratios, and not national standards, were the object of this comparison, the CCEM has decided not to publish the table of the bilateral degrees of equivalence, which are not really significant in the present case.
They can, however, be calculated by the difference of the D_i values reported below, with corresponding 95% uncertainty given, within an an approximation of about 5% or better, by twice the root-sum-square of the global standard uncertainties of the two laboratories.

Linking key comparison CCEM-K8.1 to CCEM-K8

The degree of equivalence D_i of laboratory i with respect to the key comparison reference value Δ_R, is given by the estimated difference $(\Delta_i - \Delta_R)$ that the laboratory would have obtained if it had directly participated in comparison CCEM-K8, and by the corresponding 95% expanded uncertainty U_i.

The link to CCEM-K8 is given by IEN, who was the pilot laboratory in both comparisons, with

$$D_i = (\Delta_i - \Delta_{IEN})_{CCEM\text{-}K8.1} + (\Delta_{IEN} - \Delta_R)_{CCEM\text{-}K8} = (\Delta_{i\text{-}K8.1} - \Delta_{IEN\text{-}K8.1}) + D_{IEN}$$

$$u_i = (u^2_{G.i\text{-}K8.1} + u^2_{transfer} + u^2(\Delta_R))^{1/2}$$

, where $u_{transfer}$ represents the standard uncertainty of the link to CCEM-K8, evaluated to 0.08×10^{-6}.
The degrees of freedom are taken into account in the calculation of U_i.

Linking key comparison EUROMET.EM-K8.1 to CCEM-K8

The link between EUROMET.EM-K8.1 and CCEM-K8 is computed in the same way, with $u_{transfer} = 0.08 \times 10^{-6}$. The degrees of freedom have negligible influence in the calculation of U_i.

The bilateral degrees of equivalence of laboratory i having participated in CCEM-K8.1 or EUROMET.EM-K8.1, with respect to any other laboratory participating in CCEM-K8 or EUROMET.EM-K8, can be calculated by the difference of the D_i values of the two laboratories, with corresponding 95% uncertainty given, within an approximation of 5% or better, by twice the root-sum-square of three terms: the global standard uncertainty of laboratory i, the transfer standard uncertainty $u_{transfer}$ and the global standard uncertainty of the other laboratory.

MEASURAND: DC voltage ratio 1000 V / 10 V **NOMINAL VALUE: 100**

Degrees of equivalence for participants in CCEM-K8

Lab *i* ⇩	D_i /10^{-6}	U_i /10^{-6}
LCIE	**0.42**	0.34
SP	**-0.02**	0.33
NPL	**-3.94**	0.73
CEM	**0.86**	0.59
KRISS	**0.08**	0.22
CSIRO-NML	**0.14**	0.33
NIM	**-0.21**	0.35
VNIIM	**-0.37**	0.22
NIST	**0.06**	0.49
NRC	**0.22**	0.31
MSL	**-0.03**	0.32
CSIR-NML	**-0.26**	0.61
NPLI	**0.77**	0.74
NMIJ	**-0.07**	0.28
IEN	**0.05**	0.25

Degrees of equivalence for participants in EUROMET.EM-K8

Lab *i* ⇩	D_i /10^{-6}	U_i /10^{-6}
NPL	**-0.39**	0.48
INETI	**4.27**	5.69
CEM	**0.29**	0.80
PTB	**0.06**	0.40
LCIE	**0.72**	0.37
METAS	**0.11**	0.63
CMI	**-0.64**	7.55
MIKES	**0.28**	0.48
SP	**0.23**	0.38
UME	**-2.47**	0.94
SMU	**-0.74**	2.23
NMi-VSL	**0.54**	4.87
JV	**-0.23**	0.37
SMD	**0.37**	0.88
MIRS/SIQ	**0.21**	0.65
BEV	**-0.05**	1.31
OMH	**-0.17**	1.35
EIM	**-0.69**	0.32
IEN	**0.10**	0.32

Degrees of equivalence for participant in CCEM-K8.1

Lab *i* ⇩	D_i /10^{-6}	U_i /10^{-6}
CEM	**0.47**	0.40

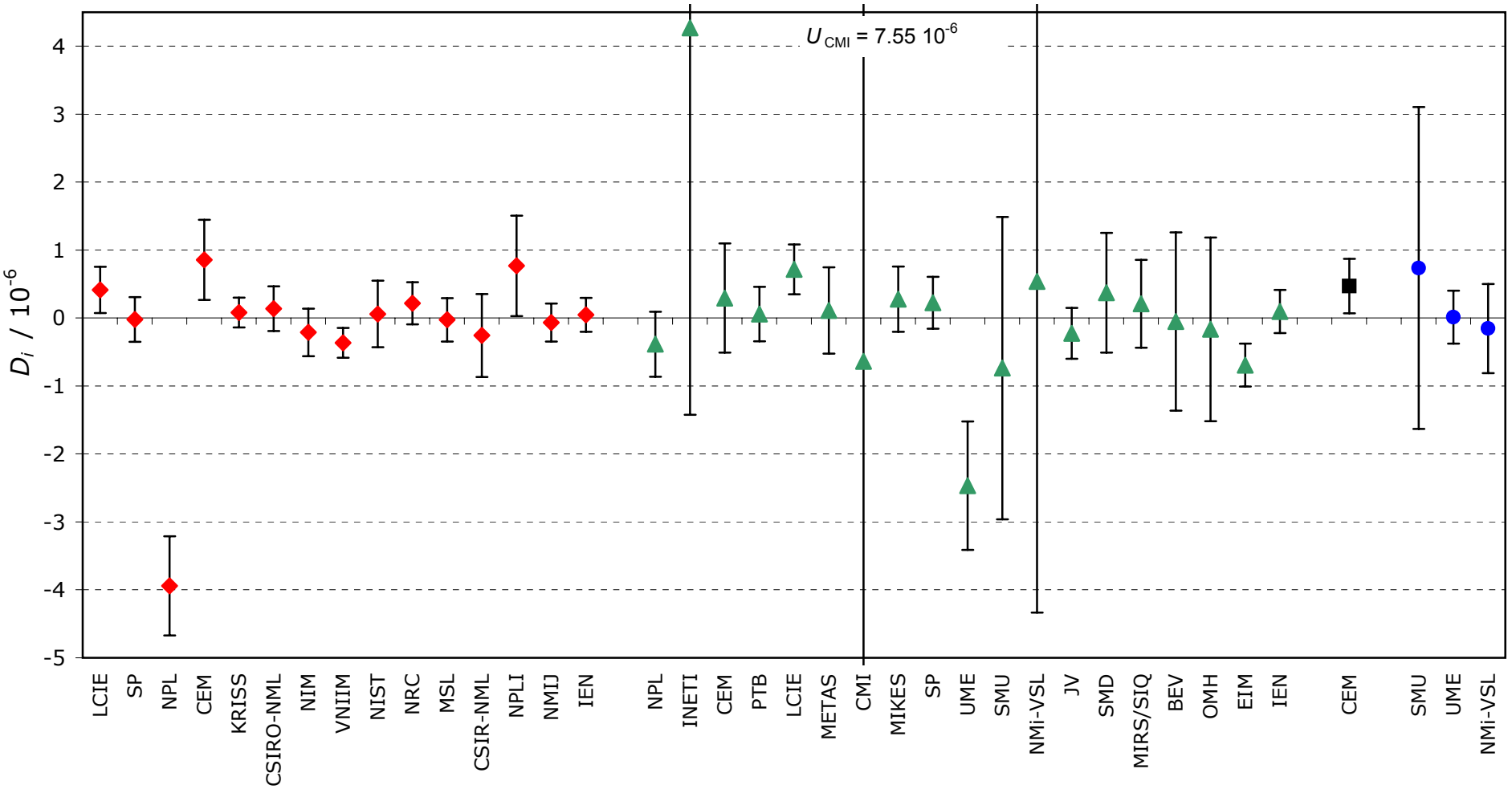
Degrees of equivalence for participant in EUROMET.EM-K8.1

Lab *i* ⇩	D_i /10^{-6}	U_i /10^{-6}
SMU	**0.74**	2.37
UME	**0.01**	0.39
NMi-VSL	**-0.16**	0.66

Laboratories which did not participate in the computation of Δ_R

Laboratories which did not participate in the computation of $\Delta_{R\text{-}EUR}$

CCEM-K8, EUROMET.EM-K8, CCEM-K8.1 and EUROMET.EM-K8.1
DC voltage ratio 1000 V / 10 V
Degrees of equivalence [D_i and expanded uncertainty U_i (95% level of confidence)]



Red diamonds: participants in CCEM-K8
Green triangles: participants in EUROMET.EM-K8
Black square: participant in CCEM-K8.1
Blue circles: participants in EUROMET.EM-K8.1

CCEM-K8, EUROMET.EM-K8, CCEM-K8.1 and EUROMET.EM-K8.1

Key comparison CCEM-K8

MEASURAND: DC voltage ratio 100 V / 10 V
NOMINAL VALUE: 10
TRAVELLING STANDARD: voltage divider Datron 4902S, s/n 20335
Pilot laboratory: IEN

$d_{0,i}$: fractional difference from nominal value of ratio $x_{0,i}$, measured by laboratory i and corrected to standard ambient conditions; it is given by: $x_{0,i} = 10 \times (1 + d_{0,i})$
The fractional differences $d_{0,IEN}$ assigned by IEN to the ratio are obtained by interpolation of the IEN measurement results to the measurement dates of the other laboratories.
$u_{G,i}$: global standard uncertainty of laboratory i
$\nu_{eff,i}$: number of effective degrees of freedom of laboratory i

Lab i	$d_{0,i}$ / 10^{-6}	$d_{0,IEN}$ / 10^{-6}	$\Delta_i = (d_{0,i} - d_{0,IEN})$ / 10^{-6}	$u_{G,i}$ / 10^{-6}	$\nu_{eff,i}$	Mean date of measurements
LCIE	-3.83	-4.04	0.21	0.14	133	1999-03-17
SP	-3.67	-3.58	-0.09	0.14	119	1999-06-04
NPL	-8.38	-3.60	-4.78	0.25	113	1999-08-20
CEM	-3.02	-3.61	0.59	0.21	15	1999-09-19
KRISS	-3.50	-3.62	0.12	0.10	32	1999-10-25
CSIRO-NML	-3.81	-3.65	-0.17	0.14	29	2000-01-08
NIM	-3.91	-3.68	-0.23	0.16	60	2000-04-10
VNIIM	-4.14	-3.71	-0.43	0.11	40	2000-07-29
NIST	-4.05	-3.74	-0.32	0.22	744	2000-10-12
NRC	-3.67	-3.74	0.07	0.10	37	2000-11-02
MSL	-3.74	-3.76	0.03	0.12	40	2001-01-06
CSIR-NML	-4.33	-3.78	-0.55	0.20	115	2001-03-01
NPLI	-2.84	-3.79	0.95	0.46	77	2001-04-07
NMIJ	-3.69	-3.81	0.12	0.09	26	2001-06-01
IEN	-	-	0.00	0.12	104	-

Key comparison EUROMET.EM-K8

MEASURAND: DC voltage ratio 100 V / 10 V
NOMINAL VALUE: 10
TRAVELLING STANDARD: voltage divider Datron 4902S, s/n 12422
Pilot laboratory: IEN

$d_{0,i\text{-EUR}}$: fractional difference from nominal value of ratio $x_{0,i\text{-EUR}}$, measured by laboratory i and corrected to standard ambient conditions; it is given by: $x_{0,i\text{-EUR}} = 100 \times (1 + d_{0,i\text{-EUR}})$
The fractional differences $d_{0,\text{IEN-EUR}}$ assigned by IEN to the ratio are obtained by interpolation of the IEN measurement results to the measurement dates of the other laboratories.

$\Delta_{i\text{-EUR}}$: $= (d_{0,i\text{-EUR}} - d_{0,\text{IEN-EUR}})$

$u_{G,i\text{-EUR}}$: global standard uncertainty of laboratory i

$\nu_{\text{eff},i\text{-EUR}}$: number of effective degrees of freedom of laboratory i

Lab i	$d_{0,i\text{-EUR}}$ / 10^{-6}	$d_{0,\text{IEN-EUR}}$ / 10^{-6}	$\Delta_{i\text{-EUR}}$ / 10^{-6}	$u_{G,i\text{-EUR}}$ / 10^{-6}	$\nu_{\text{eff},i\text{-EUR}}$	Mean date of measurements
NPL	-1.78	-1.38	-0.40	0.31	> 1000	1998-10-27
INETI	-1.00	-1.40	0.40	0.61	> 1000	1998-11-25
CEM	-1.44	-1.47	0.03	0.29	12	1999-02-17
PTB	-1.71	-1.49	-0.21	0.14	76	1999-03-16
LCIE	-1.50	-1.53	0.03	0.14	225	1999-05-05
METAS	-1.57	-1.62	0.05	0.16	89	1999-08-11
CMI	-2.48	-1.64	-0.83	0.70	> 1000	1999-09-11
MIKES	-1.74	-1.69	-0.05	0.09	39	1999-11-02
SP	-1.61	-1.71	0.10	0.12	161	1999-11-29
UME	-4.79	-1.79	-3.00	0.47	> 1000	2000-03-01
SMU	-4.23	-1.81	-2.42	1.20	> 1000	2000-03-30
NMi-VSL	-1.53	-1.84	0.31	0.66	143	2000-05-03
JV	-2.17	-2.16	-0.01	0.08	8	2000-09-17
SMD	-2.05	-2.27	0.22	0.32	> 1000	2000-10-20
MIRS/SIQ	-2.89	-2.47	-0.42	0.19	254	2000-12-16
BEV	-3.20	-3.14	-0.06	0.58	112	2001-10-17
OMH	-3.46	-3.12	-0.34	0.54	494	2001-11-15
EIM	-1.21	-3.10	1.88	0.13	127	2001-12-23
IEN	-	-	0.00	0.12	62	-

Key comparison CCEM-K8.1

CCEM-K8.1 is a follow-up comparison of CCEM-K8

MEASURAND: DC voltage ratio 100 V / 10 V
NOMINAL VALUE: 10
TRAVELLING STANDARD: voltage divider Datron 4902S, s/n 20335
Pilot laboratory: IEN

$d_{0,i\text{-K8.1}}$: fractional difference from nominal value of ratio $x_{0,i\text{-K8.1}}$, measured by laboratory *i* and corrected to standard ambient conditions; it is given by: $x_{0,i\text{-K8.1}} = 100 \times (1 + d_{0,i\text{-K8.1}})$
The fractional difference $d_{0,\text{IEN-K8.1}}$, assigned by IEN to the ratio, is obtained by interpolation of the IEN measurement results to the measurement date of the participant laboratory.

$\Delta_{i\text{-K8.1}} = (d_{0,i\text{-K8.1}} - d_{0,\text{IEN-K8.1}})$

$u_{G,i\text{-K8.1}}$: global standard uncertainty of laboratory *i*

$\nu_{\text{eff},i\text{-K8.1}}$: number of effective degrees of freedom of laboratory *i*

Lab *i*	$d_{0,i\text{-K8.1}}$ / 10^{-6}	$d_{0,\text{IEN-K8.1}}$ / 10^{-6}	$\Delta_{i\text{-K8.1}}$ / 10^{-6}	$u_{G,i\text{-K8.1}}$ / 10^{-6}	$\nu_{\text{eff},i\text{-K8.1}}$	Mean date of measurements
CEM	2.06	1.91	0.15	0.14	100	2002-11-25
IEN	-	-	0.00	0.13	23	-

Key comparison EUROMET.EM-K8.1

EUROMET.EM-K8.1 is a follow-up comparison of EUROMET.EM-K8

MEASURAND: DC voltage ratio 100 V / 10 V
NOMINAL VALUE: 10
TRAVELLING STANDARD: voltage divider Datron 4902S, s/n 20335
Pilot laboratory: IEN

$d_{0,i\text{-EUR-K8.1}}$: fractional difference from nominal value of ratio $x_{0,i\text{-EUR-K8.1}}$, measured by laboratory i and corrected to standard ambient conditions; it is given by: $x_{0,i\text{-EUR-K8.1}} = 100 \times (1 + d_{0,i\text{-EUR-K8.1}})$
The fractional differences $d_{0,\text{IEN-EUR-K8.1}}$ assigned by IEN to the ratio are obtained by interpolation of the IEN measurement results to the measurement dates of the other laboratories.

$\Delta_{i\text{-EUR-K8.1}} = (d_{0,i\text{-EUR-K8.1}} - d_{0,\text{IEN-EUR-K8.1}})$

$u_{G,i\text{-EUR-K8.1}}$: global standard uncertainty of laboratory i

$\nu_{\text{eff},i\text{-EUR-K8.1}}$: number of effective degrees of freedom of laboratory i

Lab *i*	$d_{0,i\text{-EUR-K8.1}}$ / 10^{-6}	$d_{0,\text{IEN-EUR-K8.1}}$ / 10^{-6}	$\Delta_{i\text{-EUR-K8.1}}$ / 10^{-6}	$u_{G,i\text{-EUR-K8.1}}$ / 10^{-6}	$\nu_{\text{eff},i\text{-EUR-K8.1}}$	Mean date of measurements
SMU	-1.06	-0.88	-0.18	1.20	inf.	10/11/2003
UME	-1.05	-0.90	-0.15	0.20	50	26/12/2003
NMi-VSL	-1.42	-0.93	-0.49	0.16	155	20/02/2004
IEN	-	-	0.00	0.13	120	-

CCEM-K8, EUROMET.EM-K8, CCEM-K8.1 and EUROMET.EM-K8.1

MEASURAND: DC voltage ratio 100 V / 10 V **NOMINAL VALUE: 10**

Key comparison CCEM-K8

The key comparison reference value, Δ_R, is the arithmetic mean of the differences Δ_i, obtained from thirteen participants. (Statistical tests indicate that there is a high probability that the result of each of the other two participants does not belong to the same statistical distribution as the other thirteen). The mean relative deviation of the ratio from nominal is given by the sum $\Delta_R + d_{0,IEN}$. The standard uncertainty, $u(\Delta_R)$, associated with Δ_R is the standard deviation of the mean.

Δ_R = -0.050 10^{-6} with standard uncertainty of 0.083 10^{-6} and 12 degrees of freedom.

The degree of equivalence of each laboratory with respect to the reference value is given by a pair of terms: $D_i = (\Delta_i - \Delta_R)$, and the corresponding expanded uncertainty U_i, assessed for a level of confidence of 95%. For the 13 laboratories contributing to the definition of the reference value, the correlation with the reference value is taken into account in the computation of U_i.

Key comparison EUROMET.EM-K8

The reference value, $\Delta_{R\text{-}EUR}$, is the weighted mean of the differences $\Delta_{i\text{-}EUR}$, obtained from sixteen participants. (Statistical tests indicate that there is a high probability that the result of each of the three other participants does not belong to the same statistical distribution as the other sixteen). The mean relative deviation of the ratio from nominal is given by the sum $\Delta_{R\text{-}EUR} + d_{0,IEN\text{-}EUR}$. The standard uncertainty associated with $\Delta_{R\text{-}EUR}$ is the weighted standard uncertainty.

$\Delta_{R\text{-}EUR}$ = -0.039 10^{-6} with standard uncertainty of 0.039 10^{-6} and 105 degrees of freedom.

The degree of equivalence of each laboratory with respect to the reference value is given by a pair of terms: $D_{i\text{-}EUR} = (\Delta_{i\text{-}EUR} - \Delta_{R\text{-}EUR})$, and the corresponding expanded uncertainty $U_{i\text{-}EUR}$, assessed for a level of confidence of 95%. For the 16 laboratories contributing to the definition of the reference value, the correlation with the reference value is taken into account in the computation of $U_{i\text{-}EUR}$.

Linking key comparison EUROMET.EM-K8 to CCEM-K8

In a measurement of voltage ratio, no national standard is involved. Therefore any participant in EUROMET.EM-K8 and CCEM-K8 comparisons can be considered equally able, in principle, to perform an unbiased measurement of the travelling standard. Since the number of participants in each comparison is significant and different methods of measurement were used, it is unlikely that the corresponding comparison reference values are affected by systematic errors. Therefore they are equivalent and the degrees of equivalence obtained from the EUROMET comparison are assumed to be the same as if the participants had taken part in the CCEM-K8 comparison;

$D_i = D_{i\text{-EUR}}$ and $U_i = U_{i\text{-EUR}}$ for the participants in EUROMET.EM-K8 comparison.

The linking document reports a verification of this assumption based on the results of the common participants in both comparisons.

Because voltage ratios, and not national standards, were the object of this comparison, the CCEM has decided not to publish the table of the bilateral degrees of equivalence, which are not really significant in the present case.
They can, however, be calculated by the difference of the D_i values reported below, with corresponding 95% uncertainty given, within an an approximation of about 10% or better, by twice the root-sum-square of the global standard uncertainties of the two laboratories.

Linking key comparison CCEM-K8.1 to CCEM-K8

The degree of equivalence D_i of laboratory i with respect to the key comparison reference value Δ_R, is given by the estimated difference $(\Delta_i - \Delta_R)$ that the laboratory would have obtained if it had directly participated in comparison CCEM-K8, and by the corresponding 95% expanded uncertainty U_i.

The link to CCEM-K8 is given by IEN, who was the pilot laboratory in both comparisons, with

$$D_i = (\Delta_i - \Delta_{IEN})_{CCEM\text{-}K8.1} + (\Delta_{IEN} - \Delta_R)_{CCEM\text{-}K8} = (\Delta_{i\text{-}K8.1} - \Delta_{IEN\text{-}K8.1}) + D_{IEN}$$

$$u_i = (u^2_{G.i\text{-}K8.1} + u^2_{transfer} + u^2(\Delta_R))^{1/2}$$

, where $u_{transfer}$ represents the standard uncertainty of the link to CCEM-K8, evaluated to 0.12×10^{-6}.
The degrees of freedom are taken into account in the calculation of U_i.

Linking key comparison EUROMET.EM-K8.1 to CCEM-K8

The link between EUROMET.EM-K8.1 and CCEM-K8 is computed in the same way, with $u_{transfer} = 0.12 \times 10^{-6}$. The degrees of freedom have negligible influence in the calculation of U_i.

The bilateral degrees of equivalence of laboratory i having participated in CCEM-K8.1 or EUROMET.EM-K8.1, with respect to any other laboratory participating in CCEM-K8 or EUROMET.EM-K8, can be calculated by the difference of the D_i values of the two laboratories, with corresponding 95% uncertainty given, within an approximation of 5% or better, by twice the root-sum-square of three terms: the global standard uncertainty of laboratory i, the transfer standard uncertainty $u_{transfer}$ and the global standard uncertainty of the other laboratory.

MEASURAND: DC voltage ratio 100 V / 10 V **NOMINAL VALUE: 10**

Degrees of equivalence for participants in CCEM-K8

Lab *i* ⇩	D_i /10^{-6}	U_i /10^{-6}
LCIE	**0.26**	0.30
SP	**-0.04**	0.30
NPL	**-4.73**	0.52
CEM	**0.64**	0.44
KRISS	**0.17**	0.24
CSIRO-NML	**-0.12**	0.32
NIM	**-0.18**	0.34
VNIIM	**-0.38**	0.27
NIST	**-0.27**	0.43
NRC	**0.12**	0.25
MSL	**0.08**	0.28
CSIR-NML	**-0.50**	0.40
NPLI	**1.00**	0.93
NMIJ	**0.17**	0.24
IEN	**0.05**	0.28

Laboratories which did not participate in the computation of Δ_R

Degrees of equivalence for participants in EUROMET.EM-K8

Lab *i* ⇩	D_i /10^{-6}	U_i /10^{-6}
NPL	**-0.37**	0.61
INETI	**0.44**	1.19
CEM	**0.07**	0.64
PTB	**-0.18**	0.26
LCIE	**0.07**	0.27
METAS	**0.09**	0.30
CMI	**-0.79**	1.38
MIKES	**-0.01**	0.16
SP	**0.13**	0.23
UME	**-2.96**	0.92
SMU	**-2.38**	2.36
NMi-VSL	**0.35**	1.31
JV	**0.03**	0.19
SMD	**0.26**	0.62
MIRS/SIQ	**-0.38**	0.36
BEV	**-0.02**	1.15
OMH	**-0.30**	1.07
EIM	**1.92**	0.27
IEN	**0.04**	0.23

Laboratories which did not participate in the computation of $\Delta_{R\text{-}EUR}$

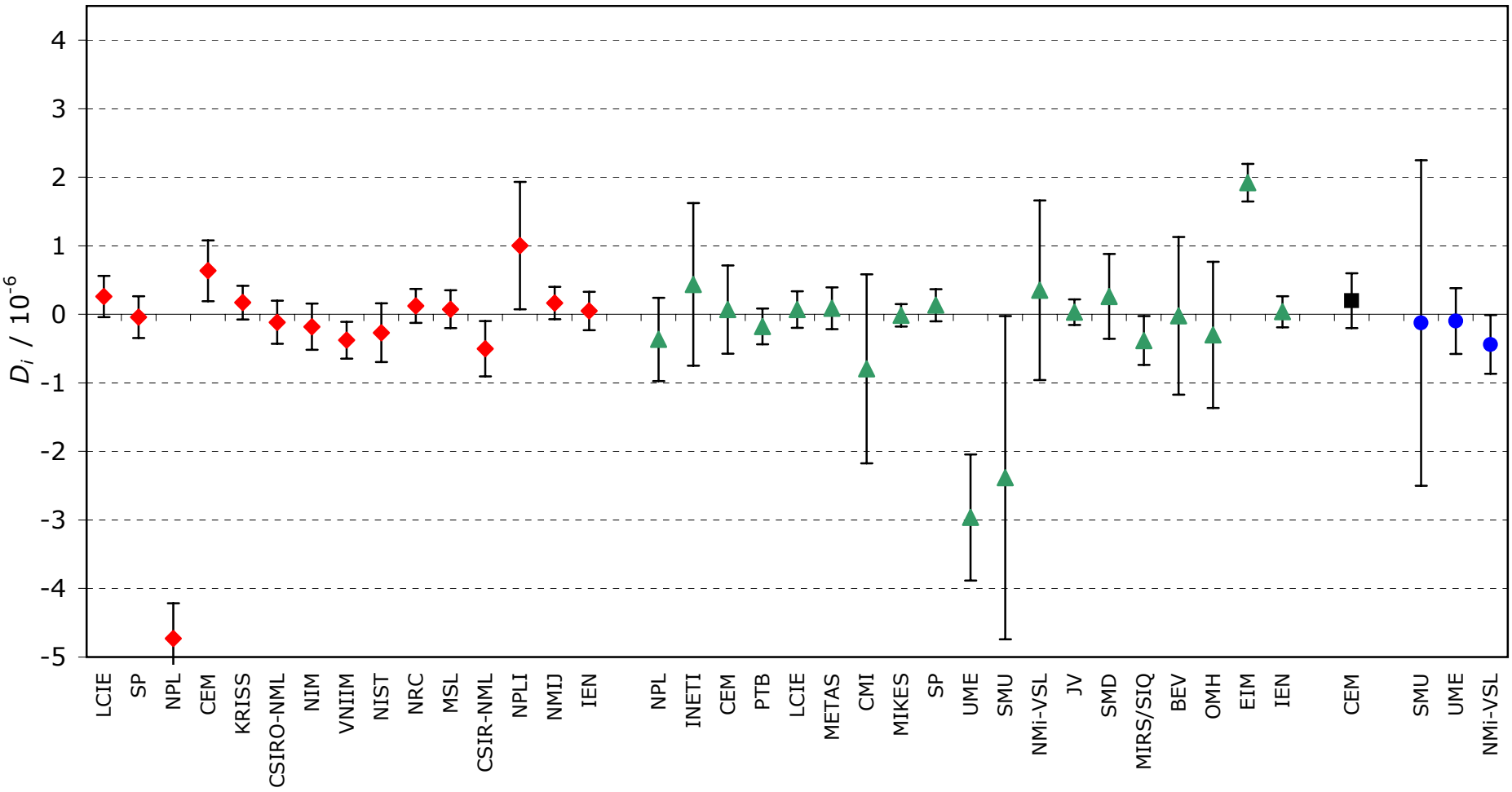
Degrees of equivalence for participant in CCEM-K8.1

Lab *i* ⇩	D_i /10^{-6}	U_i /10^{-6}
CEM	**0.20**	0.40

Degrees of equivalence for participant in EUROMET.EM-K8.1

Lab *i* ⇩	D_i /10^{-6}	U_i /10^{-6}
SMU	**-0.13**	2.38
UME	**-0.10**	0.48
NMi-VSL	**-0.44**	0.43

CCEM-K8, EUROMET.EM-K8, CCEM-K8.1 and EUROMET.EM-K8.1
DC voltage ratio 100 V / 10 V
Degrees of equivalence [D_i and expanded uncertainty U_i (95% level of confidence)]



Red diamonds: participants in CCEM-K8
Green triangles: participants in EUROMET.EM-K8
Black square: participant in CCEM-K8.1
Blue circles: participants in EUROMET.EM-K8.1