

## Key comparison CCM.M-K1

MEASURAND : Mass

NOMINAL VALUE : 1 kg

$x_{(\text{rep}) i}$  : reported result obtained as the difference between the measurement of the mass standards carried out by laboratory  $i$  (being evaluated as the average mass of two 1 kg artefacts) and the nominal value 1 kg

$u_i$  : combined standard uncertainty of  $x_{(\text{rep}) i}$

Seven participating laboratories determined the mass of the travelling standards VSL-1 and J2 (Package 1) while the remaining seven determined the mass of the travelling standards VSL-2 and J3 (Package 2).

As Pilot laboratory, the BIPM determined the mass of the travelling standards of each package at the beginning and at the end of the comparison, and a few times during the course of the comparison.

$x_i$  : difference between the mass determined by laboratory  $i$ ,  $x_{(\text{rep}) i}$ , and that determined by the Pilot laboratory.

The Pilot's mass value is the average of the two results obtained before and after the measurement at laboratory  $i$ , except for PTB and SMU where only the BIPM result of May 96 is used, and NIM where only the BIPM result of Feb 97 is used (see Final Report).

Lab $i$	$x_{(\text{rep}) i}$ / mg	$u_i$ / mg	$x_i$ / mg	Date of measurement
<b>Set of mass standards Package 1</b>				
BIPM	1.928	0.012	0.000	Feb 95
NMi-VSL	1.905	0.018	-0.018	May 95
NPL	1.923	0.016	-0.001	Jul 95
BIPM	1.918	0.012	0.000	Sep 95
VNIIM	1.963	0.024	0.046	Feb 96
BIPM	1.915	0.012	0.000	May 96
PTB	1.911	0.012	-0.004	Aug 96
SMU	1.972	0.022	0.057	Dec 96
BIPM	1.917	0.012	0.000	Feb 97
KRISS	1.913	0.014	-0.004	Mar 97
BIPM	1.918	0.012	0.000	Apr 97
LNE-INM	1.919	0.011	0.003	Jul 97
BIPM	1.914	0.012	0.000	Sep 97

Lab $i$	$x_{(\text{rep}) i}$ / mg	$u_i$ / mg	$x_i$ / mg	Date of measurement
<b>Set of mass standards Package 2</b>				
BIPM	1.803	0.012	0.000	Feb 95
NIST	1.775	0.019	-0.021	Jul 95
NRC	1.776	0.016	-0.020	Sep 95
NMIJ	1.773	0.013	-0.023	Feb 96
BIPM	1.789	0.012	0.000	May 96
NMIA	1.791	0.014	0.002	Jul 96
BIPM	1.790	0.012	0.000	Sep 96
NIM	1.830	0.021	-0.004	Oct 96
BIPM	1.835	0.012	0.000	Feb 97
BIPM	1.803	0.012	0.000	Feb 97
INRIM	1.798	0.013	-0.003	May 97
BIPM	1.799	0.012	0.000	Jun 97
CENAM	1.794	0.013	-0.001	Sep 97
BIPM	1.791	0.012	0.000	Oct 97

**Key comparison APMP.M.M-K1**

**MEASURAND :** Mass

**NOMINAL VALUE :** 1 kg

$x_{APMP i}$  : reported result, obtained as the difference between the measurement of the mass standards carried out by laboratory  $i$  and the nominal value 1 kg

$U_{APMP i}$  : expanded uncertainty ( $k = 2$ ) of  $x_{APMP i}$

As APMP.M.M-K1 Pilot laboratory, NIMT determined the mass of the travelling standards five times during the course of the comparison.

Lab $i$	$x_{APMP i}$ / mg	$U_{APMP i}$ / mg	Date of measurement
<b>Mass standard m:</b>			
NIMT-1	0.081	0.032	20 - 21 Jul 99
CMS/ITRI	0.099	0.026	19 - 27 Aug 99
NMIJ	0.115	0.076	Sep 99
NIMT-2	0.090	0.032	30 Nov - 01 Dec 99
NPLI	0.101	0.028	28 - 31 Dec 99
MSL	0.114	0.041	Feb - Mar 00
NIMT-3	0.123	0.032	30 - 31 Mar 00
NML-SIRIM	0.120	0.110	24 Apr 00
ITDI	0.281	0.073	May - Jun 00
KRISS	0.095	0.029	23 Jun - 11 Jul 00
NIMT-4	0.080	0.032	08 - 09 Aug 00
NMIA	0.094	0.030	Sep 00
SCL	0.087	0.044	Oct 00
SPRING Singapore	0.18	0.13	Nov 00
VMI-STAMEQ	-0.022	0.042	08 - 30 Dec 00
NMISA	0.100	0.040	08 Jan 01
NIS	0.039	0.041	22 - 26 Nov 01
NIMT-5	0.092	0.032	18 - 19 Jun 01

Lab $i$	$x_{APMP i}$ / mg	$U_{APMP i}$ / mg	Date of measurement
<b>Mass standard m:</b>			
NIMT-1	-0.127	0.032	20 - 21 Jul 99
CMS/ITRI	-0.113	0.026	19 - 27 Aug 99
NMIJ	-0.089	0.076	Sep 99
NIMT-2	-0.125	0.032	30 Nov - 01 Dec 99
NPLI	-0.097	0.028	28 - 31 Dec 99
MSL	-0.068	0.041	Feb - Mar 00
NIMT-3	-0.088	0.032	30 - 31 Mar 00
NML-SIRIM	-0.070	0.110	24 Apr 00
ITDI	0.118	0.069	May - Jun 00
KRISS	-0.099	0.029	23 Jun - 11 Jul 00
NIMT-4	-0.086	0.032	08 - 09 Aug 00
NMIA	-0.094	0.030	Sep 00
SCL	-0.093	0.044	Oct 00
SPRING Singapore	0.03	0.12	Nov 00
VMI-STAMEQ	-0.214	0.042	08 - 30 Dec 00
NMISA	-0.095	0.040	08 Jan 01
NIS	-0.154	0.041	22 - 26 Nov 01
NIMT-5	-0.097	0.032	18 - 19 Jun 01

**Key comparison EUROMET.M.M-K1**

**MEASURAND :** Mass

**NOMINAL VALUE :** 1 kg

$x_{EUR i}$  : reported result, obtained as the difference between the measurement of the mass standards carried out by laboratory  $i$  and the nominal value 1 kg

$u_{EUR i}$  : standard uncertainty ( $k = 1$ ) of  $x_{EUR i}$

Lab $i$	$x_{EUR i}$ / $\mu\text{g}$	$u_{EUR i}$ / $\mu\text{g}$	Date of measurement
<b>Mass standard <math>m_{PTBC}</math></b>			
JV	-577	23.5	May 1995
SP	-589	18.0	Jun 1995
MIKES	-596	17.2	Sep - Oct 1995
DFM	-571	20.0	Nov 1995
PTB	-589	14.8	Apr - May 1996
INRIM	-559	13.6	Jun - Aug 1996
NPL	-572	14.4	Aug - Sep 1996
SMD	-599	21.0	Nov 1996
LNE	-591	18.0	Dec 1996 - Feb 1997
CEM	-600	17.0	Mar - Apr 1997

Lab $i$	$x_{EUR i}$ / $\mu\text{g}$	$u_{EUR i}$ / $\mu\text{g}$	Date of measurement
<b>Mass standard <math>m_{INM11}</math></b>			
JV	2428	21.5	May 1995
SP	2411	18.0	Jun 1995
MIKES	2393	17.1	Sep - Oct 1995
DFM	2444	20.0	Nov 1995
PTB	2422	13.2	Apr - May 1996
INRIM	2451	13.9	Jun - Aug 1996
NPL	2432	14.9	Aug - Sep 1996
SMD	2401	21.0	Nov 1996
LNE	2415	18.0	Jan - Feb 1997
CEM	2412	17.1	Mar - Apr 1997

**Key comparison EUROMET.M.M-K4**

**MEASURAND :** Mass

**NOMINAL VALUE :** 1 kg

$x_{EUR4 i}$  : reported result, obtained as the difference between the measurement of the mass standards carried out by laboratory  $i$  and the nominal value 1 kg

$u_{EUR4 i}$  : standard uncertainty ( $k = 1$ ) of  $x_{EUR4 i}$

Lab $i$	$x_{EUR4 i}$ / $\mu\text{g}$	$x_{EUR4 i}$ / $\mu\text{g}$	$u_{EUR4 i}$ / $\mu\text{g}$	Date of measurement
<b>Mass standard</b>	<b><math>m_{61}</math></b>	<b><math>m_{61D}</math></b>		
SMD	-807	-997	25	Feb 2001
NMi-VSL	-799	-984	11	Mar 2001
CEM	-815	-1002	10	Apr 2001
GUM	-784	-976	29	Jun 2001
CMI	-835	-1018	70	Jul 2001
PTB	-786	-980	13	Aug 2001
SMU	-798	-985	15	Sep 2001
NPL	-802	-993	12	Sep 2001
MKEH	-808	-995	22	Nov 2001
BEV	-810	-1020	30	Dec 2001
INRIM	-806	-998	13	Feb 2002
METAS	-780	-969	15	Mar 2002
JV	-801	-986	24	May 2002
DFM	-800	-991	14	Jun 2002
SP	-798	-990	19	Jul 2002
MIKES	-810	-998	19	Aug 2002

Lab $i$	$x_{EUR4 i}$ / $\mu\text{g}$	$x_{EUR4 i}$ / $\mu\text{g}$	$u_{EUR4 i}$ / $\mu\text{g}$	Date of measurement
<b>Mass standard</b>	<b><math>m_{62DD}</math></b>	<b><math>m_{62TD}</math></b>		
METROSERT	-834	-940	35	Mar 2002
LNMC	-864	-951	82	Apr 2002
VMT/VMC	-848	-944	75	May 2002
NML(IE)	-829	-942	82	Jun 2002
MIRS	-820	-930	80	Jul 2002
EIM	-862	-966	51	Nov 2002
BIM	-835	-950	22	Oct 2002
INM(RO)	-906	-1007	24	Oct 2002
IPQ	-867	-977	54	Apr 2003

**Key comparison EUROMET.M.M-K4.1**

**MEASURAND :** Mass

**NOMINAL VALUE :** 1 kg

$x_{EUR4.1 i}$  : reported result, obtained as the difference between the measurement of the mass standards carried out by laboratory  $i$  and the nominal value 1 kg

$u_{EUR4.1 i}$  : standard uncertainty ( $k = 1$ ) of  $x_{EUR4.1 i}$

Lab $i$	$x_{EUR4.1 i}$ / $\mu\text{g}$	$u_{EUR4.1 i}$ / $\mu\text{g}$	Date of measurement
<b>Mass standard LM-006</b>			
MIRS	626	35	01 Aug 2007
DFM	634	14	23 Aug 2007
MIRS	632	35	01 Oct 2007

Lab $i$	$x_{EUR4.1 i}$ / $\mu\text{g}$	$u_{EUR4.1 i}$ / $\mu\text{g}$	Date of measurement
<b>Mass standard LM-006d</b>			
MIRS	578	35	01 Aug 2007
DFM	589	14	23 Aug 2007
MIRS	576	35	01 Oct 2007

**Key comparison APMP.M.M-K6****MEASURAND :** Mass**NOMINAL VALUE :** 1 kg

$x_{APMP6i}$  : reported result, obtained as the difference between the measurement of the mass standards carried out by laboratory  $i$  and the nominal value 1 kg

$u_{APMP6i}$  : standard combined uncertainty ( $k = 1$ ) of  $x_{APMP6i}$

As APMP.M.M-K6 Pilot laboratory, VMI-STAMEQ determined the mass of the travelling standards four times for Loop A of the comparison, and three times for Loop B of the comparison.

Lab $i$	$x_{APMP6i}$ / mg	$u_{APMP6i}$ / mg	Date of measurement
<b>Mass 1 kg</b>			
<b>Loop A</b>			
VMI-STAMEQ 1	0.069	0.0414	May 2005
NMISA	0.1	0.25	June 2005
NMIA	0.096	0.015	September 2005
VMI-STAMEQ 2	0.0705	0.0749	November 2005
ITDI	0.088	0.051	December 2005
NIMT	0.087	0.08	January 2006
VMI-STAMEQ 3	0.0625	0.0749	April 2006
NIS	-0.031	0.039	July 2006
VMI-STAMEQ 4	-0.0375	0.0749	November 2006
<b>Loop B</b>			
VMI-STAMEQ 1	-0.107	0.0365	May 2005
MUSSD	-0.172	0.26	June 2005
NPLI	-0.031	0.021	October 2005
VMI-STAMEQ 2	-0.14	0.0749	December 2005
KIM-LIPI*	-	0.03	March 2006
VMI-STAMEQ 3	-0.297	0.0749	October 2006

\* Measurement results invalidated due to damage of the transfer standards

Artefacts of nominal values 500 g, 20 g, 2 g, and 100 mg are also measured in the framework of key comparison APMP.M.M-K6. This is reported together with CCM.M-K2 results.

**Key comparison COOMET.M.M-K1**

**MEASURAND :** Mass

**NOMINAL VALUE :** 1 kg

$x_{\text{COO } i}$  : reported result, obtained as the difference between the measurement of the mass standards carried out by laboratory  $i$  and the nominal value 1 kg

$u_{\text{COO } i}$  : standard combined uncertainty ( $k = 1$ ) of  $x_{\text{COO } i}$

As COOMET.M.M-K1 Pilot laboratory, SMU determined the mass of the travelling standards three times.

Two travelling standards are used: No 04 and No 07 (results are then treated through arithmetic means)

Lab $i$	$x_{\text{COO } i}$ / mg	$u_{\text{COO } i}$ / mg	Date of measurement
<b>Mass 1 kg No 04</b>			
SMU	2.125	0.018	March 2002
NSC IM	2.128	0.016	May 2002
VNIIM	2.155	0.015	June 2002
BelGIM	1.79	0.046	March 2003
PTB	2.156	0.013	May 2003
SMU	2.14	0.018	July 2003
VMT/VMC	2.171	0.075	February 2004
SMU	2.13	0.018	May 2004
<b>Mass 1 kg No 07</b>			
SMU	-3.849	0.018	March 2002
NSC IM	-3.847	0.016	May 2002
VNIIM	-3.847	0.015	June 2002
BelGIM	-3.98	0.046	March 2003
PTB	-3.833	0.013	May 2003
SMU	-3.84	0.018	July 2003
VMT/VMC	-3.736	0.075	February 2004
SMU	-3.863	0.018	May 2004

**Key comparison APMP.M.M-K1.1**

**MEASURAND :** Mass

**NOMINAL VALUE :** 1 kg

$x_{APMP1 i}$  : reported result, obtained as the difference between the measurement of the mass standards carried out by laboratory  $i$  and the nominal value 1 kg

$U_{APMP1 i}$  : expanded uncertainty ( $k = 2$ ) of  $x_{APMP1 i}$

Pilot Laboratory: NMIA

Lab $i$	$x_{APMP1 i}$ / mg	$U_{APMP1 i}$ / mg	Date of measurement
<b>Mass standard 19029026</b>			
NMIA	0.104	0.029	Oct 2008
A*STAR	0.131	0.029	Nov 2008
NMIA	0.103	0.029	Dec 2008



**Key comparison EURAMET.M.M-K4.2****MEASURAND :**           **Mass****NOMINAL VALUE :**    **1 kg**

$x_{\text{EUR4.2 } i}$  :       reported result, obtained as the difference between the measurement of the mass standards carried out by laboratory  $i$  and the nominal value 1 kg

$U_{\text{EUR4.2 } i}$  :       expanded uncertainty ( $k = 2$ ) of  $x_{\text{EUR4.2 } i}$

<b>Lab <math>i</math></b>	<b><math>x_{\text{EUR4.2 } i}</math> / mg</b>	<b><math>U_{\text{EUR4.2 } i}</math> / mg</b>	<b>Date of measurement</b>
BEV	0.256	0.090	Feb 2010
EIM	0.181	0.154	Jan - Feb 2010
BOM	0.345	0.165	Dec 2009 - Jan 2010
DPM	0.479	1.850	Nov - Dec 2009
BMM	0.320	2.580	Oct - Nov 2009
IMBIH	0.219	0.152	Sep - Oct 2009

Key comparison CCM.M-K1

MEASURAND : Mass  
NOMINAL VALUE : 1 kg

The key comparison reference value,  $x_R$ , is evaluated as the median of the  $x_i$  values (the BIPM zero value being counted only once), and its standard uncertainty,  $u_R$ , as the standard deviation of median (see Appendix 2 of CCM.M-K1 Final Report).  
 $x_R = -3.0 \mu\text{g}$  and  $u_R = 2.2 \mu\text{g}$

The degree of equivalence of each laboratory with respect to the reference value is given by a pair of terms:

$D_i = (x_i - x_R)$  and  $U_i$ , its expanded uncertainty (at a 95% level of confidence), both expressed in  $\mu\text{g}$ .

Detailed information on the evaluation of  $U_i$  may be found in Appendix 3 of CCM.M-K1 Final Report.

The degree of equivalence between two laboratories is given by a pair of terms:

$D_{ij} = D_i - D_j = (x_i - x_j)$  and  $U_{ij}$ , its expanded uncertainty (at a 95% level of confidence), both expressed in  $\mu\text{g}$ .

Detailed information on the evaluation of  $U_{ij}$  may be found in Appendix 3 of CCM.M-K1 Final Report.

#### Linking APMP.M.M-K1 results to CCM.M-K1 results

The APMP.M.M-K1 results were analyzed and linked to the CCM.M-K1 results using Generalised Least-Squares (sometimes known as Gauss-Markov) estimation (see Section 7 of APMP.M.M-K1 Final Report).

This analysis directly combines the APMP comparison results with the CCM.M-K1 results of the three linking laboratories (KRISS, NMIA, and NMIJ) to estimate:

- the degree of equivalence of each laboratory  $i$  participant in APMP.M.M-K1 relative to the CCM.M-K1 key comparison reference value,  $D_i$  and  $U_i$ , and
- the degrees of equivalence between pairs of laboratories  $i$  and  $j$  both participant in APMP.M.M-K1,  $D_{ij}$  and  $U_{ij}$ ,  $U_i$  and  $U_{ij}$  being the expanded uncertainty ( $k = 2$ ) of  $D_i$  and  $D_{ij}$  respectively.

The degree of equivalence between two laboratories  $i$  and  $j$ , one participant in CCM.M-K1 and the other one in APMP.M.M-K1, is given by a pair of terms:  $D_{ij} = D_i - D_j$  and  $U_{ij}$ , its expanded uncertainty ( $k = 2$ ).

$U_{ij}$  may be estimated as  $U_{ij} = [U_i^2 + U_j^2 - 2(2u_R)^2]^{1/2}$  since both  $U_i$  and  $U_j$  include the uncertainty associated with the key comparison reference value. These values are not explicitly given here.

### Linking EUROMET.M.M-K1 results to CCM.M-K1 results

The EUROMET.M.M-K1 results were analyzed and linked to the CCM.M-K1 results as explained in the Linkage Report, using the values obtained by the three linking laboratories (PTB, INRIM, and NPL). It led to the estimation of:

the degree of equivalence of each laboratory  $i$  participant in EUROMET.M.M-K1 relative to the CCM.M-K1 key comparison reference value, given by the offset  $D_i$  and its expanded uncertainty ( $k = 2$ )  $U_i$ .

The pair-wise degrees of equivalence inside EUROMET.M.M-K1 are given on pages 12, 16, and 19 of the EUROMET.M.M-K1 Final Report for mass standards PTBC, INM11, and the mean of both, respectively.

### Linking EUROMET.M.M-K4 and EUROMET.M.M-K4.1 results to CCM.M-K1 results

The EUROMET.M.M-K4 and EUROMET.M.M-K4.1 results were analyzed and linked to the CCM.M-K1 results as explained in the Appendix A of the EUROMET.M.M-K4 Final report. The linking laboratories between EUROMET.M.M-K4 and CCM.M-K1 are PTB, INRIM, NMI-VSL and NPL. The linking laboratory between EUROMET.M.M-K4.1 and EUROMET.M.M-K4 is DFM.

It led to the estimation of:

the degree of equivalence of each laboratory  $i$  participant in EUROMET.M.M-K4 and K4.1 relative to the CCM.M-K1 key comparison reference value, given by the offset  $D_i$  and its expanded uncertainty ( $k = 2$ )  $U_i$ .

The pair-wise degrees of equivalence inside EUROMET.M.M-K4 are given on pages 10 to 13 of the EUROMET.M.M-K4 Final Report, and the pair-wise degree of equivalence between DFM and MIRS, as obtained in EUROMET.M.M-K4.1, on page 7 of the EUROMET.M.M-K4.1 Final Report.

### Linking APMP.M.M-K6 results to CCM.M-K1 results

The APMP.M.M-K6 results obtained for 1 kg were analyzed and linked to the CCM.M-K1 results using Generalised Least-Squares (sometimes known as Gauss-Markov) estimation (see Section 7 of APMP.M.M-K6 Final Report).

This analysis directly combines the APMP comparison results with the CCM.M-K1 results of the three linking laboratories (NMIA, NIMT, and NMISA) for Loop A, and the single linking laboratory (NPLI) for Loop B, to estimate:

- the degree of equivalence of each laboratory  $i$  participant in APMP.M.M-K6 relative to the CCM.M-K1 key comparison reference value,  $D_i$  and  $U_i$ , and
- the degrees of equivalence between pairs of laboratories  $i$  and  $j$  both participant in APMP.M.M-K6,  $D_{ij}$  and  $U_{ij}$ ,  $U_i$  and  $U_{ij}$  being the expanded uncertainties ( $k = 2$ ) of  $D_i$  and  $D_{ij}$  respectively.

The pair-wise degrees of equivalence inside APMP.M.M-K6 for 1 kg are given on page 14 of the APMP.M.M-K6 Final Report.

#### **Linking COOMET.M.M-K1 results to CCM.M-K1 results**

**The link is made using PTB values in both comparisons (see on page 6 of the COOMET.M.M-K1 Final Report)**

**The pair-wise degrees of equivalence inside COOMET.M.M-K1 are given on page 8 of the COOMET.M.M-K1 Final Report.**

#### **Linking APMP.M.M-K1.1 results to CCM.M-K1 results**

**The link is made using NMIA results in both comparisons (see Section 8 of the APMP.M.M-K1.1 Final Report)**

**The pair-wise degree of equivalence between NMIA and A\*STAR is given on page 8 of the APMP.M.M-K1.1 Final Report.**

#### **Linking EURAMET.M.M-K4.2 results to CCM.M-K1 results**

**The link is made through the EUROMET.M.M-K4 key comparison using BEV and EIM results in both comparisons (see Section 5 of the EURAMET.M.M-K4.2 Final Report)**

Key comparisons CCM.M-K1, APMP.M.M-K1, EUROMET.M.M-K1, EUROMET.M.M-K4, EUROMET.M.M-K4.1, APMP.M.M-K6, COOMET.M.M-K1, APMP.M.M-K1.1 and EURAMET.M.M-K4.2

Degrees of equivalence relative to the CCM.M-K1 key comparison reference value

Participants in CCM.M-K1

Lab *i* ↓

	$D_i$	$U_i$
	/ $\mu\text{g}$	
BIPM	3	24
NMi-VSL	-15	37
NIST	-18	39
NPL	2	32
NRC	-17	34
NMIJ	-20	28
VNIIM	49	48
NMIA	5	29
PTB	-1	26
NIM	-1	46
SMU	60	44
KRISS	-1	29
INRIM	0	27
LNE-INM	6	22
CENAM	2	27

Participants in APMP.M.M-K1

Lab *i* ↓

	$D_i$	$U_i$
	/ $\mu\text{g}$	
NIMT	-4	33
CMS/ITRI	-5	32
NMIJ	-20	28
NPLI	4	33
MSL	25	44
NML-SIRIM	27	107
ITDI	203	65
KRISS	-1	29
NMIA	4	29
SCL	-1	44
SPRING Singapore	109	96
VMI-STAMEQ	-116	45
NMISA	4	44
NIS	-56	45

Participants in EUROMET.M.M-K1

Lab *i* ↓

	$D_i$	$U_i$
	/ $\mu\text{g}$	
JV	-2	43
SP	-17	35
MIKES	-30	34
DFM	9	39
PTB	-6	25
INRIM	12	26
NPL	2	29
SMD	-27	41
LNE	-16	35
CEM	-22	33

Key comparisons CCM.M-K1, APMP.M.M-K1, EUROMET.M.M-K1, EUROMET.M.M-K4, EUROMET.M.M-K4.1, APMP.M.M-K6, COOMET.M.M-K1, APMP.M.M-K1.1 and EURAMET.M.M-K4.2

Degrees of equivalence relative to the CCM.M-K1 key comparison reference value

Participants in EUROMET.M.M-K4

Lab *i* ↓

	$D_i$	$U_i$
	/ $\mu\text{g}$	
SMD	-18	48
NMi-VSL	-5	23
CEM	-23	22
GUM	8	56
CMI	-38	130
PTB	4	25
SMU	-1	30
NPL	-7	25
MKEH	-9	43
BEV	-21	57
INRIM	-5	26
METAS	23	30
JV	6	46
DFM	5	29
SP	7	38
MIKES	-2	38
METROSERT	13	67
LNMC	-7	152
VMT/VMC	5	139
NML(IE)	16	152
MIRS	26	149
EIM	-11	96
BIM	10	43
INM(RO)	-54	47
IPQ	-17	101

Participants in EUROMET.M.M-K4.1

Lab *i* ↓

	$D_i$	$U_i$
	/ $\mu\text{g}$	
DFM	5	29
MIRS	-4	73

Artefacts of nominal values 500 g, 20 g, 2 g, and 100 mg are also measured in the framework of key comparison APMP.M.M-K6. This is reported together with CCM.M-K2 results.

Participants in APMP.M.M-K6

Lab *i* ↓

	$D_i$	$U_i$
	/ $\mu\text{g}$	
VMI-STAMEQ	-23	73
NMISA	4	44
NMIA	5	30
ITDI	-3	102
NIMT	-4	34
NIS	-122	78
MUSSD	-137	521
NPLI	4	34
KIM-LIPI	-	-

Participants in COOMET.M.M-K1

Lab *i* ↓

	$D_i$	$U_i$
	/ $\mu\text{g}$	
SMU	-21	44
NSC IM	-21	42
VNIIM	-8	40
BelGIM	-257	242
PTB	-1	26
VMT/VMC	56	152

Participants in APMP.M.M-K1.1

Lab *i* ↓

	$D_i$	$U_i$
	/ $\mu\text{g}$	
NMIA	5	30
A*STAR	33	49

Participants in EURAMET.M.M-K4.2

Lab *i* ↓

	$D_i$	$U_i$
	/ $\mu\text{g}$	
BEV	19	46
EIM	-55	133
BOM	109	145
DPM	243	1848
BMM	84	2579
IMBIH	-17	131

CCM.M-K1 Matrix of equivalence

Lab <i>i</i> ↓	$D_i$ $U_i$		Lab <i>j</i> →													
	/ μg		BIPM		NMI-VSL		NIST		NPL		NRC		NMIJ		VNIIM	
	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$
BIPM	3	24														
NMI-VSL	-15	37	-18	44			3	54	-17	48	2	50	5	46	-64	61
NIST	-18	39	-21	46	-3	54									-67	62
NPL	2	32	-1	40	17	48	20	50							-47	58
NRC	-17	34	-20	41	-2	50	1	50	-19	46			4	42	-66	59
NMIJ	-20	28	-23	36	-5	46	-2	47	-23	42	-4	42			-69	56
VNIIM	49	48	46	54	64	61	67	62	47	58	66	59	69	56		
NMIA	5	29	2	37	20	46	23	48	2	43	21	44	25	39	-44	56
PTB	-1	26	-4	35	14	44	17	46	-4	41	15	42	19	37	-50	54
NIM	-1	46	-4	51	14	58	17	60	-4	55	15	56	19	53	-50	66
SMU	60	44	57	50	75	57	78	59	58	54	77	55	80	52	11	65
KRISS	-1	29	-4	37	14	46	17	48	-4	43	16	44	19	39	-50	56
INRIM	0	27	-3	35	15	45	18	47	-2	41	17	42	20	38	-49	55
LNE-INM	6	22	3	32	21	42	24	45	4	38	23	40	26	35	-43	53
CENAM	2	27	-1	36	17	45	20	47	-1	41	19	43	22	38	-47	55

Lab <i>i</i> ↓	$D_i$ $U_i$		Lab <i>j</i> →															
	/ μg		NMIA		PTB		NIM		SMU		KRISS		INRIM		LNE-INM		CENAM	
	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$
BIPM	3	24	-2	37	4	35	4	51	-57	50	4	37	3	35	-3	32	1	36
NMI-VSL	-15	37	-20	46	-14	44	-14	58	-75	57	-14	46	-15	45	-21	42	-17	45
NIST	-18	39	-23	48	-17	46	-17	60	-78	59	-17	48	-18	47	-24	45	-20	47
NPL	2	32	-2	43	4	41	4	55	-58	54	4	43	2	41	-4	38	1	41
NRC	-17	34	-21	44	-15	42	-15	56	-77	55	-16	44	-17	42	-23	40	-19	43
NMIJ	-20	28	-25	39	-19	37	-19	53	-80	52	-19	39	-20	38	-26	35	-22	38
VNIIM	49	48	44	56	50	54	50	66	-11	65	50	56	49	55	43	53	47	55
NMIA	5	29			6	38	6	54	-55	52	6	40	5	39	-1	36	3	39
PTB	-1	26	-6	38			0	52	-61	51	0	38	-1	36	-7	33	-3	37
NIM	-1	46	-6	54	0	52			-61	63	0	54	-1	53	-7	50	-3	53
SMU	60	44	55	52	61	51	61	63			61	52	60	51	54	49	58	52
KRISS	-1	29	-6	40	0	38	0	54	-61	52			-1	39	-7	36	-3	39
INRIM	0	27	-5	39	1	36	1	53	-60	51	1	39			-6	34	-2	38
LNE-INM	6	22	1	36	7	33	7	50	-54	49	7	36	6	34			4	34
CENAM	2	27	-3	39	3	37	3	53	-58	52	3	39	2	38	-4	34		

APMP.M.M-K1 Matrix of equivalence

Lab <i>i</i> ↓	$D_i$ $U_i$		Lab <i>j</i> →													
	/ $\mu\text{g}$		NIMT		CMS/ITRI		NMIJ		NPLI		MSL		NML-SIRIM		ITDI	
	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$
NIMT	-4	33														
CMS/ITRI	-5	32	-1	38												
NMIJ	-20	28	-16	39	-14	37										
NPLI	4	33	8	40	9	38	23	39								
MSL	25	44	29	49	30	38	44	48	21	49						
NML-SIRIM	27	107	31	109	32	109	46	35	23	109	2	113				
ITDI	203	65	207	59	208	68	223	68	199	68	178	74	176	123		
KRISS	-1	29	3	39	4	38	19	35	-5	39	-26	49	-28	109	-204	68
NMIA	4	29	9	17	10	38	24	35	1	39	-20	49	-22	109	-198	58
SCL	-1	44	3	49	4	48	18	48	-5	49	-26	57	-28	113	-204	74
SPRING Singapore	109	96	113	99	114	98	129	98	105	99	84	90	82	142	-94	113
VMI-STAMEQ	-116	45	-112	50	-111	49	-97	50	-120	50	-141	58	-143	113	-319	75
NMISA	4	44	8	49	10	47	24	48	1	48	-21	56	-23	113	-199	74
NIS	-56	45	-52	50	-51	49	-36	49	-60	50	-81	57	-83	113	-259	75

Lab <i>i</i> ↓	$D_i$ $U_i$		Lab <i>j</i> →													
	/ $\mu\text{g}$		KRISS		NMIA		SCL		SPRING		VMI		NMISA		NIS	
	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$	$D_{ij}$	$U_{ij}$
NIMT	-4	33	-3	39	-9	17	-3	49	-113	99	112	50	-8	49	52	50
CMS/ITRI	-5	32	-4	38	-10	38	-4	48	-114	98	111	49	-10	47	51	49
NMIJ	-20	28	-19	35	-24	35	-18	48	-129	98	97	50	-24	48	36	49
NPLI	4	33	5	39	-1	39	5	49	-105	99	120	50	-1	48	60	50
MSL	25	44	26	49	20	49	26	57	-84	90	141	58	21	56	81	57
NML-SIRIM	27	107	28	109	22	109	28	113	-82	142	143	113	23	113	83	113
ITDI	203	65	204	68	198	58	204	74	94	113	319	75	199	74	259	75
KRISS	-1	29			-6	36	0	48	-110	99	115	50	-6	48	55	49
NMIA	4	29	6	36			6	48	-104	99	121	50	0	48	60	49
SCL	-1	44	0	48	-6	48			-110	103	115	58	-6	56	55	57
SPRING Singapore	109	96	110	99	104	99	110	103			225	103	105	103	165	103
VMI-STAMEQ	-116	45	-115	50	-121	50	-115	58	-225	103			-121	57	-61	58
NMISA	4	44	6	48	0	48	6	56	-105	103	121	57			60	57
NIS	-56	45	-55	49	-60	49	-55	57	-165	103	61	58	-60	57		



**CCM.M-K1, APMP.M.M-K1, K1.1, EUROMET.M.M-K1, -K4, -K4.1, K4.2, APMP.M.M-K6 and COOMET.M.M-K1: 1 kg**  
**Degrees of equivalence:  $D_i$  and expanded uncertainty  $U_i$**

