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Report on EUROMET key comparison of multiples and submultiples of the kilogram (EUROMET.M.M-K2)

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Department for **Innovation, Universities** & **Skills**

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ABSTRACT

This report summarises the results of a EUROMET comparison of multiples and submultiples of the kilogram carried out between twenty-five laboratories. The transfer standards comprised five sets of weights (each set comprising 10 kg, 500 g, 20 g, 2 g and 100 mg) which were circulated in parallel, each set between five of the listed participants. The majority of the results of the participants are consistent with each other and with the key comparison reference value (KCRV) of comparison CCM.M-K2 to which this comparison has been linked.

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Contents

1 Introduction

In 1999 CCM key comparison CCM.M-K2 was completed [1]. The comparison was carried out using mass standards of the following five nominal values:

100 mg, 2 g, 20 g, 500 g and 10 kg.

Fourteen national measurement institutes took part in the comparison, thirteen being member countries of the CCM and seven being member countries of EUROMET.

It was agreed that a European regional key comparison should be carried out over the same range to link with CCM.M-K2. SP (Sweden) agreed to take the role as pilot laboratory and to provide the transfer standards and NPL (UK) took on the role of collation and analysis of the results. Further management responsibilities were undertaken by OMH (Hungary).

Twenty-five laboratories took part in the comparison. They are listed in Table 1.

Table 1: List of Participating Laboratories

Laboratory		Country
Bundesamt fur Eich- und Vermessungswesen	BEV	Austria
Metrology Division, FPS Economy	SMD	Belgium
GD National Center of Metrology	NCM	Bulgaria
Czech Metrological Institute	CMI	Czech Republic
Danish Institute of Fundamental Metrology	DFM	Denmark
Metrosert	METROSERT	Estonia
Mittatekniikan keskus	MIKES	Finland
Physikalisch-Technische Bundesanstalt	PTB	Germany
Hellenic Institute of Metrology	EIM	Greece
National Office of Measures	OMH	Hungary
National Metrology Laboratory	NML	Ireland
Istituto Nazionale di Ricerca Metrologica	INRIM	Italy
Latvijas Nacionālais Metroloģijas Centrs	LNMC	Latvia
Vilnius Metrology Centre	VMC	Lithuania
Nederlands Meetinstituut-Van Swinden Laboratorium	NMi VSL	Netherlands
Justervesenet	JV	Norway
Central Office of Measures	GUM	Poland
Instituto Português da Qualidade	IPQ	Portugal
National Institute Of Metrology	INM	Romania
Slovak Institute of Metrology	SMU	Slovakia
Metrology Institute of the Republic of Slovenia	MIRS	Slovenia
Centro Español de Metrologia	CEM	Spain
SP Measurement Technology	SP	Sweden
Swiss Federal Office of Metrology and Accreditation	METAS	Switzerland
Tübitak Ulusal Metroloji Enstitüsü	UME	Turkey

Five sets of transfer standards (EB, EC, ED, EE and EF) were circulated in parallel, each between five of the listed participants, the groupings being decided on broadly geographical lines. In addition, a further set (EA) was retained at SP for the duration of the comparison.

The masses of each of the transfer standard sets (including EA) were determined by SP at the beginning and end of the comparison process. The data from these determinations were used to provide a measure of stability of the transfer standards. As well as providing the initial and final measurements of the transfer standards, SP were also a participant carrying out their measurements on transfer standard set ED.

The comparison measurements were carried out between August 2002 and June 2003. As is common with many comparisons, there was a significant delay in many participants supplying their results, the last of which were not received until February 2004.

This report details and analyses the results obtained by the participants. Different methods of determination of a reference value were considered. These were:

- using the median and calculating the associated uncertainty based upon the method described by Müller [2];
- using the least squares method;
- using a method described by Cox [3] which utilises Monte Carlo simulation.

The consensus of the participants was to use the median and the uncertainty analysis of Müller. The disadvantage of this method is the relatively large uncertainty in the reference value and thus in the degree of equivalence of the participants. This can be overcome to some extent by taking into account the covariances that exist between each individual result and the reference value. For the purposes of this comparison this analysis was undertaken by INRIM and is fully described by Pennecchi and Bich [4].

2 Description of the transfer standards

Each of the transfer standard sets supplied by SP comprised five weights made from non-magnetic stainless steel and with the form and quality recommended by OIML [5] for weights of accuracy Class E_1. Transportation was undertaken by hand, with the weights being carried within a purpose-built wooden box.

3 Summary of results reported by the participants

3.1 Values of mass and uncertainty

The results and uncertainties provided by each of the participants for each of the nominal mass values are shown in Table 2. Each result is shown as the difference between the mass determined by the participant (m) and the nominal mass value (m_o), in mg. The uncertainties (u_c) are given in mg at k=1 .

3.2 Stability of the transfer standards

Results obtained by SP for each of the transfer standard sets (including the non-circulated set EA) are shown in Table 3. As in Table 2, the results are shown as the difference in mg

between the mass determined by SP (m) and the nominal mass value (m_o), together with the associated uncertainty (u_c) at k=1.

Little difference in the magnitude of the changes in mass can be observed between the non-travelling set EA and the other five sets. In addition, any observed changes are, in the majority of cases, at the level of or below the associated uncertainties. The transfer standards were therefore assumed to be stable.

4 Mass differences

Each participant reported their measured mass difference from the nominal value together with an associated uncertainty for each of the five weights. In order to compare the values from all of the participants it is necessary to link them to initial reference values for each set obtained from the pre- (m_{p1}) and post- (m_{p2}) circulation measurements of the pilot laboratory, SP (as there is no indication of when any change in the mass value occurred, the best estimate of the pilot laboratory's mass value is the mean of these two measurements).

Thus, the mass difference between participant A and the pilot laboratory P is calculated from:

$$\Delta m_{A,P} = m_A - \frac{m_{P1} + m_{P2}}{2} \tag{1}$$

5 Calculation of comparison reference value and uncertainty

The comparison reference value has been taken to be the median of the calculated differences between each participant and the pilot laboratory's mean value. As described in the CCM report, a major consideration for adopting this approach is its reduced sensitivity to outliers and the fact that it does not require the exclusion of data, as would be the case when calculating a mean value only from data showing a positive t-test.

The reference value m_{ref} can therefore be defined as:

$$m_{ref} = median(\Delta m_{i,P})_{i=1\ to\ n} \tag{2}$$

The uncertainty in the reference value has been calculated according to the method described by Müller [3]. The five reference values and their associated uncertainties are shown in Table 4.

Table 4: Reference values and associated uncertainties for EUROMET comparison

Nominal Mass	Reference Value mg	Uncertainty (k=1) mg
10 kg	0.44	0.14
500 g	-0.019	0.005
20 g	-0.001	0.001
2 g	-0.001 0	0.000 3
100 mg	-0.000 2	0.000 2

6 Mass difference and uncertainty between participants and reference value

The mass difference between a participant and the reference value is calculated from:

$$\Delta m_{\mathrm{A,ref}} = \Delta m_{\mathrm{A,P}} - m_{\mathrm{ref}} \tag{3}$$

The uncertainties have been calculated in accordance with the international guide [6]. The uncertainty of the difference between a participant's measurement and the reference value is made up of four components:

- the uncertainty in the participant's measurement
- the uncertainty due to the drift of the transfer standard
- the uncertainty in the pilot laboratory's measurement of the drift
- the uncertainty in the reference value.

The uncertainty due to the instability of the transfer standard can be assumed to be a rectangular distribution within the limits of m_{P1} and m_{P2} and the uncertainty in the reference value is as calculated in section 5. The other uncertainties are as provided by the participants and the pilot laboratory.

The uncertainty is therefore calculated from:

$$u_{\mathrm{A}}(\Delta m_{\mathrm{ref,A}}) = \sqrt{u^2(\Delta m_{\mathrm{A,P}}) + u^2(m_{\mathrm{ref}}) - 2\,\mathrm{cov}\left(\Delta m_{\mathrm{A,P}}, m_{\mathrm{ref}}\right)} \tag{4}$$

where

$$u^2(\Delta m_{\mathrm{A,P}}) = u^2(m_{\mathrm{A}}) + u^2(\Delta m_{\mathrm{P}}) + \frac{(m_{P2} - m_{P1})^2}{12} \tag{5}$$

and the covariance term was calculated using the method described by Pennecchi and Bich [4].

The differences between each participant and the reference value, together with their associated uncertainties, are given in Table 5 and shown graphically in Figures 1 to 5.

7 Mass differences and uncertainties between participants

7.1 Mass differences

Mass differences between participants A and B are calculated by subtracting the difference between participant B and the reference value from the difference between participant A and the reference value. These differences are given in Table 6 to Table 10, together with their associated uncertainties which have been calculated as described in Sections 7.2 and 1.

The mass difference is therefore given by:

$$\Delta m_{\mathrm{A,B}} = \Delta m_{\mathrm{ref,A}} - \Delta m_{\mathrm{ref,B}} \tag{6}$$

7.2 Uncertainties in mass differences between A and B of different loops

The mass differences between A and B of two different loops is calculated using the reference value as a link, with the measurements considered to be uncorrelated. The uncertainty in their difference comprises the following contributions:

- the uncertainty in participant A's measurement
- the uncertainty in participant B's measurement
- the uncertainty due to the drift of the transfer standard in the loop containing A
- the uncertainty due to the drift of the transfer standard in the loop containing B
- the uncertainty in the pilot laboratory's measurements of the drift for the loop containing A
- the uncertainty in the pilot laboratory's measurements of the drift for the loop containing B

The uncertainty is therefore calculated from:

$$u_{\mathrm{a}}(\Delta m_{\mathrm{A,B}}) = \sqrt{u_{\mathrm{c}}^2(m_{\mathrm{A}}) + u_{\mathrm{c}}^2(m_{\mathrm{B}}) + 2u_{\mathrm{c}}^2(\Delta m_{\mathrm{P}}) + \frac{(m_{P2} - m_{P1})^2}{12} + \frac{(m_{P4} - m_{P3})^2}{12}} \tag{7}$$

7.3 Uncertainties in mass differences between A and B of the same loop

The mass differences between A and B of the same loop is similarly treated, but with uncertainty contributions from only one loop. The uncertainty in their difference comprises the following contributions:

- the uncertainty in participant A's measurement
- the uncertainty in participant B's measurement
- the uncertainty due to the drift of the transfer standard in the loop containing A and B
- the uncertainty in the pilot laboratory's measurements of the drift for the loop containing A and B

The uncertainty is therefore calculated from:

$$u_{\mathrm{a}}(\Delta m_{\mathrm{A,B}}) = \sqrt{u_{\mathrm{c}}^2(m_{\mathrm{A}}) + u_{\mathrm{c}}^2(m_{\mathrm{B}}) + u_{\mathrm{c}}^2(\Delta m_{\mathrm{P}}) + \frac{(m_{P2} - m_{P1})^2}{12}} \qquad (8)$$

8 Linkage to key comparison CCM.M-K2

The results of this comparison have been linked to the results of the key comparison CCM.M-K2 using a method based upon that of Sutton [7] as described in Appendix A.

9 References

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[6] Guide to the Expression of Uncertainty in Measurement, BIPM, IEC, IFCC, ISO, IUPAC, IUPAP, OIML, 1993

[7] Sutton C M, Metrologia, **41** 272-277, 2004

10 Tables of Results

Table 2: Reported results for the five sets of travelling standards, shown as the difference between mass, m, and nominal mass, m_0, and standard uncertainty (k=1).

		10 kg		500 g		20 g		2 g		100 mg	
Set	Laboratory	$m-m_0$/mg	u_c/mg	$m-m_0$/mg	u_c/mg	$m-m_0$/mg	u_c/mg	$m-m_0$/mg	u_c/mg	$m-m_0$/mg	u_c/mg
EB	IPQ	--	--	0.032	0.031	0.0062	0.0029	0.0025	0.0019	0.0000	0.0007
	CEM	-1.72	0.37	0.034	0.008	0.0047	0.0020	0.0027	0.0006	-0.0001	0.0002
	SMD	-1.91	0.49	0.047	0.013	0.0061	0.0016	0.0024	0.0007	0.0001	0.0003
	NMi VSL	-0.46	0.75	0.056	0.038	0.0140	0.0040	0.0028	0.0020	0.0005	0.0008
	NML	-0.29	1.10	0.042	0.062	0.0030	0.0050	0.0040	0.0030	0.0000	0.0010
EC	EIM	8.63	0.87	-0.082	0.042	-0.0034	0.0047	0.0021	0.0035	-0.0008	0.0009
	UME	15.00	0.40	0.137	0.009	-0.0010	0.0010	0.0027	0.0004	-0.0004	0.0001
	INM	9.13	0.19	-0.050	0.020	0.0050	0.0020	0.0045	0.0015	0.0001	0.0009
	NCM	10.00	13.00	-0.081	0.041	0.0050	0.0047	0.0030	0.0031	0.0010	0.0017
	OMH	9.17	0.25	-0.035	0.013	0.0038	0.0019	0.0033	0.0005	0.0015	0.0002
ED	JV	0.80	0.82	-0.194	0.033	0.0104	0.0028	0.0013	0.0016	-0.0005	0.0007
	SP	0.00	0.72	-0.114	0.018	0.0070	0.0030	0.0040	0.0021	-0.0004	0.0006
	MIKES	0.36	0.55	-0.117	0.021	0.0040	0.0040	0.0025	0.0014	-0.0013	0.0005
	METROSERT	-0.40	3.20	-0.104	0.022	0.0033	0.0021	0.0016	0.0010	-0.0013	0.0006
	LNMC	0.22	1.69	-0.103	0.056	0.0058	0.0040	-0.0013	0.0026	-0.0018	0.0007
EE	DFM	-2.07	0.73	-0.008	0.007	0.0050	0.0022	0.0017	0.0010	0.0012	0.0004
	PTB	-1.29	0.40	-0.010	0.007	0.0017	0.0004	0.0012	0.0002	0.0015	0.0001
	CMI	-1.00	1.50	0.035	0.025	-0.0020	0.0060	0.0010	0.0030	0.0020	0.0012
	GUM	0.20	1.10	0.020	0.020	0.0090	0.0040	0.0040	0.0010	0.0005	0.0004
	VMC	0.90	1.60	-0.013	0.080	0.0106	0.0050	0.0110	0.0090	-0.0014	0.0015
EF	SMU	-0.57	0.46	-0.082	0.010	0.0041	0.0030	0.0035	0.0017	-0.0036	0.0007
	BEV	-1.20	0.70	-0.110	0.020	0.0070	0.0020	0.0040	0.0010	-0.0015	0.0003
	METAS	-1.24	0.45	-0.105	0.016	0.0059	0.0026	0.0026	0.0010	-0.0013	0.0003
	INRIM	-1.25	0.40	-0.117	0.007	0.0013	0.0010	0.0034	0.0007	-0.0011	0.0003
	MIRS	-1.14	0.75	-0.123	0.038	0.0034	0.0040	0.0031	0.0020	-0.0012	0.0008

Table 3: Results obtained by pilot laboratory, SP, for each of the weight sets shown as the difference between mass, m, and nominal mass, m_0, and standard uncertainty (k=1).

		10 kg		500 g		20 g		2 g		100 mg	
Set	Date	$m-m_0$/mg	u_c/mg	$m-m_0$/mg	u_c/mg	$m-m_0$/mg	u_c/mg	$m-m_0$/mg	u_c/mg	$m-m_0$/mg	u_c/mg
EA	May 2002	0.10	0.80	-0.020	0.040	0.001 0	0.003 0	0.007 0	0.003 0	-0.001 4	0.000 7
	Nov 2002	0.20	0.80	-0.030	0.040	0.000 0	0.003 0	0.005 0	0.003 0	-0.001 3	0.000 7
	Feb 2003	0.00	0.80	-0.010	0.040	0.003 0	0.003 0	0.005 0	0.003 0	-0.001 5	0.000 7
	Nov 2003	0.30	0.70	-0.020	0.030	-0.003 0	0.004 0	0.005 0	0.001 0	-0.000 9	0.000 6
EB	May 2002	-2.20	0.80	0.050	0.030	0.009 0	0.004 0	0.004 0	0.002 0	-0.000 1	0.000 8
	Nov 2003	-1.90	0.70	0.050	0.030	0.002 0	0.003 0	0.006 0	0.001 0	0.000 5	0.000 6
EC	May 2002	8.00	0.80	-0.070	0.020	0.004 0	0.005 0	0.003 0	0.003 0	0.000 1	0.000 7
	Nov 2003	8.30	0.70	-0.030	0.020	0.002 0	0.004 0	0.004 0	0.001 0	0.001 2	0.000 5
ED	May 2002	-0.20	0.80	-0.100	0.030	0.016 0	0.004 0	0.005 0	0.002 0	-0.001 4	0.000 8
	Nov 2003	0.20	0.80	-0.070	0.020	0.010 0	0.004 0	0.003 0	0.001 0	-0.000 7	0.000 6
EE	May 2002	-1.80	0.80	0.010	0.020	0.010 0	0.004 0	0.003 0	0.002 0	0.001 2	0.000 8
	Nov 2003	-1.60	0.70	0.030	0.020	0.005 0	0.008 0	0.002 0	0.001 0	0.000 8	0.000 6
EF	May 2002	-1.60	0.80	-0.100	0.020	0.008 0	0.005 0	0.004 0	0.002 0	-0.001 2	0.000 8
	Nov 2003	-1.20	0.80	-0.070	0.020	0.000 0	0.003 0	0.004 0	0.001 0	-0.000 9	0.000 6

Table 5: Differences between participants' results and reference value, Δm, and associated k=2 uncertainties, $U_{\Delta m}$

		IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
10 kg	Δm/mg		-0.11	-0.30	1.15	1.32	0.04	6.41	0.54	1.41	0.58	0.36	-0.44	-0.08
	$U_{\Delta m}$/mg		0.56	0.96	1.38	2.10	1.48	0.83	0.31	25.92	0.43	1.44	1.43	0.90
500 g	Δm/mg	0.001	0.003	0.016	0.025	0.011	-0.013	0.206	0.019	-0.012	0.034	-0.090	-0.010	-0.013
	$U_{\Delta m}$/mg	0.053	0.011	0.021	0.074	0.117	0.085	0.030	0.041	0.079	0.034	0.068	0.034	0.042
20 g	Δm/mg	0.002	0.000	0.001	0.009	-0.002	-0.006	-0.003	0.003	0.003	0.002	-0.002	-0.005	-0.008
	$U_{\Delta m}$/mg	0.007	0.005	0.005	0.010	0.010	0.010	0.004	0.005	0.010	0.004	0.011	0.010	0.012
2 g	Δm/mg	-0.001 5	-0.001 3	-0.001 6	-0.001 2	0.000 0	-0.000 4	0.000 2	0.002 0	0.000 5	0.000 8	-0.001 7	0.001 0	-0.000 5
	$U_{\Delta m}$/mg	0.005 4	0.004 0	0.004 3	0.005 5	0.006 7	0.007 6	0.003 7	0.005 0	0.007 0	0.003 9	0.005 2	0.005 7	0.004 7
100 mg	Δm/mg	0.000 0	-0.000 1	0.000 1	0.000 5	0.000 0	-0.001 3	-0.000 9	-0.000 4	0.000 6	0.001 0	0.000 7	0.000 9	-0.000 1
	$U_{\Delta m}$/mg	0.001 3	0.000 7	0.000 8	0.001 7	0.001 9	0.002 0	0.001 0	0.001 9	0.003 4	0.001 1	0.001 5	0.001 4	0.001 1

		METROS	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
10 kg	Δm/mg	-0.84	-0.22	-0.81	-0.04	0.26	1.46	2.16	0.39	-0.24	-0.28	-0.29	-0.18
	$U_{\Delta m}$/mg	6.37	3.20	1.45	0.54	2.77	2.17	3.17	0.77	1.27	0.81	0.76	1.32
500 g	Δm/mg	0.000	0.001	-0.009	-0.011	0.034	0.019	-0.014	0.022	-0.006	-0.001	-0.013	-0.019
	$U_{\Delta m}$/mg	0.038	0.105	0.013	0.014	0.051	0.038	0.159	0.024	0.036	0.027	0.020	0.076
20 g	Δm/mg	-0.009	-0.006	-0.002	-0.005	-0.009	0.002	0.004	0.001	0.004	0.003	-0.002	0.000
	$U_{\Delta m}$/mg	0.010	0.011	0.005	0.005	0.013	0.008	0.011	0.007	0.007	0.007	0.006	0.008
2 g	Δm/mg	-0.001 4	-0.004 3	0.000 2	-0.000 3	-0.000 5	0.002 5	0.009 5	0.000 5	0.001 0	-0.000 4	0.000 4	0.000 1
	$U_{\Delta m}$/mg	0.004 4	0.006 6	0.004 0	0.003 5	0.006 8	0.004 5	0.018 4	0.004 9	0.004 3	0.004 0	0.003 8	0.005 1
100 mg	Δm/mg	-0.000 1	-0.000 6	0.000 4	0.000 7	0.001 2	-0.000 3	-0.002 2	-0.002 4	-0.000 3	0.000 0	0.000 2	0.000 1
	$U_{\Delta m}$/mg	0.001 3	0.001 5	0.001 0	0.000 8	0.002 5	0.001 0	0.003 1	0.001 6	0.000 8	0.000 7	0.000 8	0.001 5

Table 6A: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 10 kg

Δm/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ													
CEM			0.19	-1.26	-1.44	-0.15	-6.52	-0.65	-1.52	-0.69	-0.47	0.33	-0.03
SMD		-0.19		-1.45	-1.63	-0.34	-6.71	-0.84	-1.71	-0.88	-0.66	0.14	-0.22
NMi VSL		1.26	1.45		-0.18	1.11	-5.26	0.61	-0.26	0.57	0.79	1.59	1.23
NML		1.44	1.63	0.18		1.29	-5.09	0.78	-0.08	0.74	0.97	1.77	1.41
EIM		0.15	0.34	-1.11	-1.29		-6.37	-0.50	-1.37	-0.54	-0.32	0.48	0.12
UME		6.52	6.71	5.26	5.09	6.37		5.87	5.00	5.83	6.05	6.85	6.49
INM		0.65	0.84	-0.61	-0.78	0.50	-5.87		-0.87	-0.04	0.18	0.98	0.62
NCM		1.52	1.71	0.26	0.08	1.37	-5.00	0.87		0.83	1.05	1.85	1.49
OMH		0.69	0.88	-0.57	-0.74	0.54	-5.83	0.04	-0.83		0.22	1.02	0.66
JV		0.47	0.66	-0.79	-0.97	0.32	-6.05	-0.18	-1.05	-0.22		0.80	0.44
SP		-0.33	-0.14	-1.59	-1.77	-0.48	-6.85	-0.98	-1.85	-1.02	-0.80		-0.36
MIKES		0.03	0.22	-1.23	-1.41	-0.12	-6.49	-0.62	-1.49	-0.66	-0.44	0.36	

$U_{\Delta m}$/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ													
CEM			1.24	1.68	2.33	1.91	1.12	0.87	26.01	0.93	1.82	1.65	1.36
SMD		1.24		1.80	2.41	2.01	1.29	1.08	26.02	1.13	1.93	1.77	1.50
NMi VSL		1.68	1.80		2.67	2.31	1.72	1.57	26.04	1.60	2.24	2.10	1.88
NML		2.33	2.41	2.67		2.82	2.35	2.25	26.09	2.27	2.76	2.65	2.48
EIM		1.91	2.01	2.31	2.82		1.92	1.79	26.06	1.82	2.41	2.28	2.08
UME		1.12	1.29	1.72	2.35	1.92		0.90	26.01	0.96	1.85	1.67	1.39
INM		0.87	1.08	1.57	2.25	1.79	0.90		26.00	0.65	1.71	1.52	1.20
NCM		26.01	26.02	26.04	26.09	26.06	26.01	26.00		26.01	26.05	26.04	26.02
OMH		0.93	1.13	1.60	2.27	1.82	0.96	0.65	26.01		1.74	1.55	1.24
JV		1.82	1.93	2.24	2.76	2.41	1.85	1.71	26.05	1.74		2.20	1.99
SP		1.65	1.77	2.10	2.65	2.28	1.67	1.52	26.04	1.55	2.20		1.83
MIKES		1.36	1.50	1.88	2.48	2.08	1.39	1.20	26.02	1.24	1.99	1.83	

Table 6B: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 10 kg

Δm/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT		-0.73	-0.54	-1.99	-2.17	-0.88	-7.25	-1.38	-2.25	-1.42	-1.20	-0.40	-0.76
LNMC		-0.11	0.08	-1.37	-1.55	-0.26	-6.63	-0.76	-1.63	-0.80	-0.58	0.22	-0.14
DFM		-0.70	-0.51	-1.96	-2.14	-0.85	-7.22	-1.35	-2.22	-1.39	-1.17	-0.37	-0.73
PTB		0.08	0.27	-1.18	-1.36	-0.07	-6.44	-0.57	-1.44	-0.62	-0.39	0.41	0.05
CMI		0.37	0.56	-0.89	-1.07	0.22	-6.15	-0.28	-1.15	-0.32	-0.10	0.70	0.34
GUM		1.57	1.76	0.31	0.14	1.42	-4.95	0.92	0.05	0.88	1.10	1.90	1.54
VMC		2.27	2.46	1.01	0.84	2.12	-4.25	1.62	0.75	1.58	1.80	2.60	2.24
SMU		0.50	0.69	-0.76	-0.94	0.35	-6.02	-0.15	-1.02	-0.19	0.03	0.83	0.47
BEV		-0.13	0.06	-1.39	-1.57	-0.28	-6.65	-0.78	-1.65	-0.82	-0.60	0.20	-0.16
METAS		-0.17	0.02	-1.43	-1.60	-0.32	-6.69	-0.82	-1.69	-0.86	-0.64	0.16	-0.20
INRIM		-0.18	0.01	-1.44	-1.62	-0.33	-6.70	-0.83	-1.70	-0.87	-0.65	0.15	-0.21
MIRS		-0.07	0.12	-1.33	-1.51	-0.22	-6.59	-0.72	-1.59	-0.76	-0.54	0.26	-0.10

$U_{\Delta m}$/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT		6.45	6.48	6.58	6.77	6.64	6.46	6.42	26.78	6.43	6.61	6.56	6.50
LNMC		3.47	3.53	3.71	4.04	3.81	3.49	3.41	26.22	3.43	3.76	3.68	3.56
DFM		1.65	1.77	2.10	2.65	2.28	1.68	1.52	26.04	1.56	2.21	2.07	1.85
PTB		1.11	1.28	1.71	2.35	1.93	1.15	0.91	26.01	0.97	1.84	1.67	1.39
CMI		3.10	3.16	3.36	3.73	3.47	3.11	3.03	26.17	3.05	3.43	3.34	3.21
GUM		2.33	2.42	2.67	3.12	2.81	2.35	2.24	26.09	2.27	2.76	2.64	2.47
VMC		3.29	3.35	3.54	3.89	3.65	3.31	3.23	26.20	3.25	3.61	3.52	3.39
SMU		1.22	1.38	1.78	2.40	1.99	1.25	1.04	26.02	1.09	1.91	1.74	1.47
BEV		1.61	1.73	2.07	2.62	2.25	1.64	1.48	26.04	1.52	2.18	2.04	1.81
METAS		1.20	1.36	1.77	2.39	1.98	1.23	1.01	26.02	1.07	1.90	1.73	1.46
INRIM		1.13	1.30	1.73	2.36	1.94	1.17	0.93	26.01	0.99	1.85	1.68	1.40
MIRS		1.70	1.82	2.14	2.68	2.32	1.73	1.58	26.04	1.61	2.25	2.11	1.89

Table 6C: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 10 kg

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ												
CEM	0.73	0.11	0.70	-0.08	-0.37	-1.57	-2.27	-0.50	0.13	0.17	0.18	0.07
SMD	0.54	-0.08	0.51	-0.27	-0.56	-1.76	-2.46	-0.69	-0.06	-0.02	-0.01	-0.12
NMi VSL	1.99	1.37	1.96	1.18	0.89	-0.31	-1.01	0.76	1.39	1.43	1.44	1.33
NML	2.17	1.55	2.14	1.36	1.07	-0.14	-0.84	0.94	1.57	1.60	1.62	1.51
EIM	0.88	0.26	0.85	0.07	-0.22	-1.42	-2.12	-0.35	0.28	0.32	0.33	0.22
UME	7.25	6.63	7.22	6.44	6.15	4.95	4.25	6.02	6.65	6.69	6.70	6.59
INM	1.38	0.76	1.35	0.57	0.28	-0.92	-1.62	0.15	0.78	0.82	0.83	0.72
NCM	2.25	1.63	2.22	1.44	1.15	-0.05	-0.75	1.02	1.65	1.69	1.70	1.59
OMH	1.42	0.80	1.39	0.62	0.32	-0.88	-1.58	0.19	0.82	0.86	0.87	0.76
JV	1.20	0.58	1.17	0.39	0.10	-1.10	-1.80	-0.03	0.60	0.64	0.65	0.54
SP	0.40	-0.22	0.37	-0.41	-0.70	-1.90	-2.60	-0.83	-0.20	-0.16	-0.15	-0.26
MIKES	0.76	0.14	0.73	-0.05	-0.34	-1.54	-2.24	-0.47	0.16	0.20	0.21	0.10

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ												
CEM	6.45	3.47	1.65	1.11	3.10	2.33	3.29	1.22	1.61	1.20	1.13	1.70
SMD	6.48	3.53	1.77	1.28	3.16	2.42	3.35	1.38	1.73	1.36	1.30	1.82
NMi VSL	6.58	3.71	2.10	1.71	3.36	2.67	3.54	1.78	2.07	1.77	1.73	2.14
NML	6.77	4.04	2.65	2.35	3.73	3.12	3.89	2.40	2.62	2.39	2.36	2.68
EIM	6.64	3.81	2.28	1.93	3.47	2.81	3.65	1.99	2.25	1.98	1.94	2.32
UME	6.46	3.49	1.68	1.15	3.11	2.35	3.31	1.25	1.64	1.23	1.17	1.73
INM	6.42	3.41	1.52	0.91	3.03	2.24	3.23	1.04	1.48	1.01	0.93	1.58
NCM	26.78	26.22	26.04	26.01	26.17	26.09	26.20	26.02	26.04	26.02	26.01	26.04
OMH	6.43	3.43	1.56	0.97	3.05	2.27	3.25	1.09	1.52	1.07	0.99	1.61
JV	6.61	3.76	2.21	1.84	3.43	2.76	3.61	1.91	2.18	1.90	1.85	2.25
SP	6.56	3.68	2.07	1.67	3.34	2.64	3.52	1.74	2.04	1.73	1.68	2.11
MIKES	6.50	3.56	1.85	1.39	3.21	2.47	3.39	1.47	1.81	1.46	1.40	1.89

Table 6D: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 10 kg

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		-0.62	-0.03	-0.81	-1.10	-2.30	-3.00	-1.23	-0.60	-0.56	-0.55	-0.66
LNMC	0.62		0.59	-0.19	-0.48	-1.68	-2.38	-0.61	0.02	0.06	0.07	-0.04
DFM	0.03	-0.59		-0.78	-1.07	-2.27	-2.97	-1.20	-0.57	-0.53	-0.52	-0.63
PTB	0.81	0.19	0.78		-0.29	-1.49	-2.19	-0.42	0.21	0.25	0.26	0.15
CMI	1.10	0.48	1.07	0.29		-1.20	-1.90	-0.13	0.50	0.54	0.55	0.44
GUM	2.30	1.68	2.27	1.49	1.20		-0.70	1.07	1.70	1.74	1.75	1.64
VMC	3.00	2.38	2.97	2.19	1.90	0.70		1.77	2.40	2.44	2.45	2.34
SMU	1.23	0.61	1.20	0.42	0.13	-1.07	-1.77		0.63	0.67	0.68	0.57
BEV	0.60	-0.02	0.57	-0.21	-0.50	-1.70	-2.40	-0.63		0.04	0.05	-0.06
METAS	0.56	-0.06	0.53	-0.25	-0.54	-1.74	-2.44	-0.67	-0.04		0.01	-0.10
INRIM	0.55	-0.07	0.52	-0.26	-0.55	-1.75	-2.45	-0.68	-0.05	-0.01		-0.11
MIRS	0.66	0.04	0.63	-0.15	-0.44	-1.64	-2.34	-0.57	0.06	0.10	0.11	

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		7.24	6.57	6.46	7.07	6.77	7.16	6.47	6.56	6.47	6.46	6.58
LNMC	7.24		3.69	3.48	4.53	4.04	4.66	3.52	3.67	3.51	3.49	3.71
DFM	6.57	3.69		1.67	3.34	2.64	3.52	1.75	2.04	1.73	1.69	2.11
PTB	6.46	3.48	1.67		3.11	2.34	3.30	1.25	1.63	1.23	1.16	1.72
CMI	7.07	4.53	3.34	3.11		3.72	4.39	3.15	3.32	3.14	3.12	3.36
GUM	6.77	4.04	2.64	2.34	3.72		3.89	2.40	2.62	2.39	2.36	2.68
VMC	7.16	4.66	3.52	3.30	4.39	3.89		3.34	3.50	3.33	3.31	3.54
SMU	6.47	3.52	1.75	1.25	3.15	2.40	3.34		1.69	1.30	1.24	1.78
BEV	6.56	3.67	2.04	1.63	3.32	2.62	3.50	1.69		1.68	1.63	2.07
METAS	6.47	3.51	1.73	1.23	3.14	2.39	3.33	1.30	1.68		1.22	1.76
INRIM	6.46	3.49	1.69	1.16	3.12	2.36	3.31	1.24	1.63	1.22		1.72
MIRS	6.58	3.71	2.11	1.72	3.36	2.68	3.54	1.78	2.07	1.76	1.72	

Table 7A: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 500 g

Δm/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ		-0.002	-0.015	-0.024	-0.010	0.014	-0.205	-0.018	0.013	-0.033	0.091	0.011	0.014
CEM	0.002		-0.013	-0.022	-0.008	0.016	-0.203	-0.016	0.015	-0.031	0.093	0.013	0.016
SMD	0.015	0.013		-0.009	0.005	0.029	-0.190	-0.003	0.028	-0.018	0.106	0.026	0.029
NMi VSL	0.024	0.022	0.009		0.014	0.038	-0.181	0.006	0.037	-0.009	0.115	0.035	0.038
NML	0.010	0.008	-0.005	-0.014		0.024	-0.195	-0.008	0.023	-0.023	0.101	0.021	0.024
EIM	-0.014	-0.016	-0.029	-0.038	-0.024		-0.219	-0.032	-0.001	-0.047	0.077	-0.003	0.000
UME	0.205	0.203	0.190	0.181	0.195	0.219		0.187	0.218	0.172	0.296	0.216	0.219
INM	0.018	0.016	0.003	-0.006	0.008	0.032	-0.187		0.031	-0.015	0.109	0.029	0.032
NCM	-0.013	-0.015	-0.028	-0.037	-0.023	0.001	-0.218	-0.031		-0.046	0.078	-0.002	0.001
OMH	0.033	0.031	0.018	0.009	0.023	0.047	-0.172	0.015	0.046		0.124	0.044	0.047
JV	-0.091	-0.093	-0.106	-0.115	-0.101	-0.077	-0.296	-0.109	-0.078	-0.124		-0.080	-0.077
SP	-0.011	-0.013	-0.026	-0.035	-0.021	0.003	-0.216	-0.029	0.002	-0.044	0.080		0.003
MIKES	-0.014	-0.016	-0.029	-0.038	-0.024	0.000	-0.219	-0.032	-0.001	-0.047	0.077	-0.003	

$U_{\Delta m}$/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ		0.064	0.067	0.098	0.139	0.107	0.069	0.078	0.105	0.071	0.093	0.074	0.077
CEM	0.064		0.031	0.078	0.125	0.089	0.035	0.050	0.087	0.039	0.071	0.044	0.049
SMD	0.067	0.031		0.081	0.127	0.091	0.040	0.054	0.089	0.044	0.074	0.048	0.053
NMi VSL	0.098	0.078	0.081		0.146	0.116	0.082	0.089	0.114	0.084	0.102	0.086	0.089
NML	0.139	0.125	0.127	0.146		0.152	0.128	0.133	0.150	0.129	0.142	0.131	0.132
EIM	0.107	0.089	0.091	0.116	0.152		0.089	0.096	0.120	0.091	0.111	0.096	0.099
UME	0.069	0.035	0.040	0.082	0.128	0.089		0.050	0.087	0.039	0.075	0.050	0.055
INM	0.078	0.050	0.054	0.089	0.133	0.096	0.050		0.094	0.053	0.083	0.062	0.065
NCM	0.105	0.087	0.089	0.114	0.150	0.120	0.087	0.094		0.089	0.109	0.094	0.097
OMH	0.071	0.039	0.044	0.084	0.129	0.091	0.039	0.053	0.089		0.077	0.053	0.057
JV	0.093	0.071	0.074	0.102	0.142	0.111	0.075	0.083	0.109	0.077		0.077	0.080
SP	0.074	0.044	0.048	0.086	0.131	0.096	0.050	0.062	0.094	0.053	0.077		0.058
MIKES	0.077	0.049	0.053	0.089	0.132	0.099	0.055	0.065	0.097	0.057	0.080	0.058	

Table 7B: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 500 g

Δm/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT	-0.001	-0.003	-0.016	-0.025	-0.011	0.013	-0.206	-0.019	0.012	-0.034	0.090	0.010	0.013
LNMC	0.000	-0.002	-0.015	-0.024	-0.010	0.014	-0.205	-0.018	0.013	-0.033	0.091	0.011	0.014
DFM	-0.010	-0.011	-0.025	-0.034	-0.020	0.005	-0.215	-0.028	0.004	-0.043	0.082	0.002	0.005
PTB	-0.012	-0.014	-0.027	-0.036	-0.022	0.002	-0.217	-0.030	0.001	-0.045	0.079	-0.001	0.002
CMI	0.033	0.031	0.018	0.009	0.023	0.047	-0.172	0.015	0.046	0.000	0.124	0.044	0.047
GUM	0.018	0.016	0.003	-0.006	0.008	0.032	-0.187	0.000	0.031	-0.015	0.109	0.029	0.032
VMC	-0.015	-0.017	-0.030	-0.039	-0.025	-0.001	-0.220	-0.033	-0.002	-0.048	0.076	-0.004	-0.001
SMU	0.021	0.019	0.006	-0.003	0.011	0.035	-0.184	0.003	0.034	-0.012	0.112	0.032	0.035
BEV	-0.007	-0.009	-0.022	-0.031	-0.017	0.007	-0.212	-0.025	0.006	-0.040	0.084	0.004	0.007
METAS	-0.002	-0.004	-0.017	-0.026	-0.012	0.012	-0.207	-0.020	0.011	-0.035	0.089	0.009	0.012
INRIM	-0.014	-0.016	-0.029	-0.038	-0.024	0.000	-0.219	-0.032	-0.001	-0.047	0.077	-0.003	0.000
MIRS	-0.020	-0.022	-0.035	-0.044	-0.030	-0.006	-0.225	-0.038	-0.007	-0.053	0.071	-0.009	-0.006

$U_{\Delta m}$/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT	0.078	0.051	0.055	0.090	0.133	0.099	0.056	0.067	0.097	0.059	0.081	0.060	0.064
LNMC	0.129	0.115	0.117	0.137	0.168	0.143	0.117	0.123	0.142	0.119	0.131	0.119	0.121
DFM	0.065	0.026	0.033	0.079	0.126	0.090	0.036	0.051	0.087	0.040	0.071	0.045	0.050
PTB	0.065	0.025	0.033	0.078	0.126	0.089	0.035	0.050	0.087	0.039	0.071	0.045	0.049
CMI	0.081	0.054	0.058	0.092	0.134	0.101	0.060	0.070	0.099	0.062	0.086	0.066	0.069
GUM	0.075	0.045	0.050	0.087	0.131	0.097	0.052	0.063	0.095	0.054	0.080	0.058	0.062
VMC	0.172	0.161	0.163	0.178	0.203	0.183	0.163	0.167	0.182	0.164	0.175	0.166	0.167
SMU	0.068	0.032	0.038	0.081	0.127	0.091	0.040	0.054	0.089	0.044	0.074	0.049	0.053
BEV	0.076	0.047	0.051	0.088	0.132	0.098	0.053	0.064	0.096	0.056	0.081	0.060	0.064
METAS	0.072	0.040	0.045	0.084	0.129	0.095	0.047	0.059	0.092	0.050	0.077	0.054	0.058
INRIM	0.066	0.029	0.035	0.080	0.126	0.090	0.038	0.052	0.088	0.042	0.072	0.047	0.051
MIRS	0.099	0.079	0.082	0.109	0.146	0.117	0.083	0.090	0.115	0.085	0.103	0.087	0.090

Table 7C: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 500 g

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ	0.001	0.000	0.010	0.012	-0.033	-0.018	0.015	-0.021	0.007	0.002	0.014	0.020
CEM	0.003	0.002	0.011	0.014	-0.031	-0.016	0.017	-0.019	0.009	0.004	0.016	0.022
SMD	0.016	0.015	0.025	0.027	-0.018	-0.003	0.030	-0.006	0.022	0.017	0.029	0.035
NMi VSL	0.025	0.024	0.034	0.036	-0.009	0.006	0.039	0.003	0.031	0.026	0.038	0.044
NML	0.011	0.010	0.020	0.022	-0.023	-0.008	0.025	-0.011	0.017	0.012	0.024	0.030
EIM	-0.013	-0.014	-0.005	-0.002	-0.047	-0.032	0.001	-0.035	-0.007	-0.012	0.000	0.006
UME	0.206	0.205	0.215	0.217	0.172	0.187	0.220	0.184	0.212	0.207	0.219	0.225
INM	0.019	0.018	0.028	0.030	-0.015	0.000	0.033	-0.003	0.025	0.020	0.032	0.038
NCM	-0.012	-0.013	-0.004	-0.001	-0.046	-0.031	0.002	-0.034	-0.006	-0.011	0.001	0.007
OMH	0.034	0.033	0.043	0.045	0.000	0.015	0.048	0.012	0.040	0.035	0.047	0.053
JV	-0.090	-0.091	-0.082	-0.079	-0.124	-0.109	-0.076	-0.112	-0.084	-0.089	-0.077	-0.071
SP	-0.010	-0.011	-0.002	0.001	-0.044	-0.029	0.004	-0.032	-0.004	-0.009	0.003	0.009
MIKES	-0.013	-0.014	-0.005	-0.002	-0.047	-0.032	0.001	-0.035	-0.007	-0.012	0.000	0.006

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ	0.078	0.129	0.065	0.065	0.081	0.075	0.172	0.068	0.076	0.072	0.066	0.099
CEM	0.051	0.115	0.026	0.025	0.054	0.045	0.161	0.032	0.047	0.040	0.029	0.079
SMD	0.055	0.117	0.033	0.033	0.058	0.050	0.163	0.038	0.051	0.045	0.035	0.082
NMi VSL	0.090	0.137	0.079	0.078	0.092	0.087	0.178	0.081	0.088	0.084	0.080	0.109
NML	0.133	0.168	0.126	0.126	0.134	0.131	0.203	0.127	0.132	0.129	0.126	0.146
EIM	0.099	0.143	0.090	0.089	0.101	0.097	0.183	0.091	0.098	0.095	0.090	0.117
UME	0.056	0.117	0.036	0.035	0.060	0.052	0.163	0.040	0.053	0.047	0.038	0.083
INM	0.067	0.123	0.051	0.050	0.070	0.063	0.167	0.054	0.064	0.059	0.052	0.090
NCM	0.097	0.142	0.087	0.087	0.099	0.095	0.182	0.089	0.096	0.092	0.088	0.115
OMH	0.059	0.119	0.040	0.039	0.062	0.054	0.164	0.044	0.056	0.050	0.042	0.085
JV	0.081	0.131	0.071	0.071	0.086	0.080	0.175	0.074	0.081	0.077	0.072	0.103
SP	0.060	0.119	0.045	0.045	0.066	0.058	0.166	0.049	0.060	0.054	0.047	0.087
MIKES	0.064	0.121	0.050	0.049	0.069	0.062	0.167	0.053	0.064	0.058	0.051	0.090

Table 7D: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 500 g

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		-0.001	0.009	0.011	-0.034	-0.019	0.014	-0.022	0.006	0.001	0.013	0.019
LNMC	0.001		0.010	0.012	-0.033	-0.018	0.015	-0.021	0.007	0.002	0.014	0.020
DFM	-0.009	-0.010		0.003	-0.043	-0.028	0.006	-0.031	-0.003	-0.008	0.005	0.011
PTB	-0.011	-0.012	-0.003		-0.045	-0.030	0.003	-0.033	-0.005	-0.011	0.002	0.008
CMI	0.034	0.033	0.043	0.045		0.015	0.048	0.012	0.040	0.035	0.047	0.053
GUM	0.019	0.018	0.028	0.030	-0.015		0.033	-0.003	0.025	0.020	0.032	0.038
VMC	-0.014	-0.015	-0.006	-0.003	-0.048	-0.033		-0.036	-0.008	-0.013	-0.001	0.005
SMU	0.022	0.021	0.031	0.033	-0.012	0.003	0.036		0.028	0.023	0.035	0.041
BEV	-0.006	-0.007	0.003	0.005	-0.040	-0.025	0.008	-0.028		-0.005	0.007	0.013
METAS	-0.001	-0.002	0.008	0.011	-0.035	-0.020	0.013	-0.023	0.005		0.012	0.018
INRIM	-0.013	-0.014	-0.005	-0.002	-0.047	-0.032	0.001	-0.035	-0.007	-0.012		0.006
MIRS	-0.019	-0.020	-0.011	-0.008	-0.053	-0.038	-0.005	-0.041	-0.013	-0.018	-0.006	

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		0.122	0.052	0.051	0.070	0.064	0.167	0.055	0.065	0.060	0.053	0.091
LNMC	0.122		0.115	0.115	0.125	0.121	0.197	0.117	0.122	0.119	0.116	0.137
DFM	0.052	0.115		0.024	0.054	0.045	0.161	0.034	0.048	0.041	0.030	0.080
PTB	0.051	0.115	0.024		0.053	0.044	0.161	0.033	0.048	0.041	0.030	0.079
CMI	0.070	0.125	0.054	0.053		0.065	0.168	0.058	0.068	0.063	0.057	0.093
GUM	0.064	0.121	0.045	0.044	0.065		0.165	0.050	0.061	0.055	0.048	0.088
VMC	0.167	0.197	0.161	0.161	0.168	0.165		0.163	0.166	0.165	0.162	0.178
SMU	0.055	0.117	0.034	0.033	0.058	0.050	0.163		0.048	0.041	0.031	0.080
BEV	0.065	0.122	0.048	0.048	0.068	0.061	0.166	0.048		0.054	0.046	0.087
METAS	0.060	0.119	0.041	0.041	0.063	0.055	0.165	0.041	0.054		0.039	0.083
INRIM	0.053	0.116	0.030	0.030	0.057	0.048	0.162	0.031	0.046	0.039		0.079
MIRS	0.091	0.137	0.080	0.079	0.093	0.088	0.178	0.080	0.087	0.083	0.079	

Table 8A: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 20 g

Δm/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ	0.000	0.002	0.000	-0.008	0.003	0.007	0.005	-0.001	-0.001	0.000	0.003	0.007	0.010
CEM	-0.002	0.000	-0.001	-0.009	0.002	0.006	0.003	-0.003	-0.003	-0.002	0.002	0.005	0.008
SMD	0.000	0.001	0.000	-0.008	0.003	0.007	0.005	-0.001	-0.001	0.000	0.003	0.007	0.010
NMi VSL	0.008	0.009	0.008	0.000	0.011	0.015	0.013	0.007	0.007	0.008	0.011	0.015	0.018
NML	-0.003	-0.002	-0.003	-0.011	0.000	0.004	0.002	-0.005	-0.005	-0.003	0.000	0.004	0.007
EIM	-0.007	-0.006	-0.007	-0.015	-0.004	0.000	-0.002	-0.008	-0.008	-0.007	-0.004	0.000	0.003
UME	-0.005	-0.003	-0.005	-0.013	-0.002	0.002	0.000	-0.006	-0.006	-0.005	-0.001	0.002	0.005
INM	0.001	0.003	0.001	-0.007	0.005	0.008	0.006	0.000	0.000	0.001	0.005	0.008	0.011
NCM	0.001	0.003	0.001	-0.007	0.005	0.008	0.006	0.000	0.000	0.001	0.005	0.008	0.011
OMH	0.000	0.002	0.000	-0.008	0.003	0.007	0.005	-0.001	-0.001	0.000	0.003	0.007	0.010
JV	-0.003	-0.002	-0.003	-0.011	0.000	0.004	0.001	-0.005	-0.005	-0.003	0.000	0.003	0.006
SP	-0.007	-0.005	-0.007	-0.015	-0.004	0.000	-0.002	-0.008	-0.008	-0.007	-0.003	0.000	0.003
MIKES	-0.010	-0.008	-0.010	-0.018	-0.007	-0.003	-0.005	-0.011	-0.011	-0.010	-0.006	-0.003	0.000

$U_{\Delta m}$/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ	0.000	0.009	0.009	0.011	0.013	0.013	0.009	0.010	0.013	0.010	0.011	0.011	0.013
CEM	0.009	0.000	0.008	0.011	0.012	0.012	0.008	0.009	0.012	0.009	0.010	0.011	0.012
SMD	0.009	0.008	0.000	0.010	0.012	0.012	0.008	0.009	0.012	0.009	0.010	0.010	0.012
NMi VSL	0.011	0.011	0.010	0.000	0.014	0.014	0.011	0.011	0.014	0.011	0.012	0.013	0.014
NML	0.013	0.012	0.012	0.014	0.000	0.015	0.012	0.013	0.015	0.013	0.014	0.014	0.015
EIM	0.013	0.012	0.012	0.014	0.015	0.000	0.010	0.011	0.014	0.011	0.013	0.013	0.014
UME	0.009	0.008	0.008	0.011	0.012	0.010	0.000	0.006	0.010	0.006	0.009	0.009	0.011
INM	0.010	0.009	0.009	0.011	0.013	0.011	0.006	0.000	0.011	0.007	0.010	0.010	0.011
NCM	0.013	0.012	0.012	0.014	0.015	0.014	0.010	0.011	0.000	0.011	0.013	0.013	0.014
OMH	0.010	0.009	0.009	0.011	0.013	0.011	0.006	0.007	0.011	0.000	0.010	0.010	0.011
JV	0.011	0.010	0.010	0.012	0.014	0.013	0.009	0.010	0.013	0.010	0.000	0.010	0.011
SP	0.011	0.011	0.010	0.013	0.014	0.013	0.009	0.010	0.013	0.010	0.010	0.000	0.011
MIKES	0.013	0.012	0.012	0.014	0.015	0.014	0.011	0.011	0.014	0.011	0.011	0.011	0.000

Table 8B: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 20 g

Δm/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT	-0.010	-0.009	-0.010	-0.018	-0.007	-0.003	-0.006	-0.012	-0.012	-0.011	-0.007	-0.004	-0.001
LNMC	-0.008	-0.006	-0.008	-0.016	-0.005	-0.001	-0.003	-0.009	-0.009	-0.008	-0.005	-0.001	0.002
DFM	-0.003	-0.002	-0.003	-0.011	0.000	0.004	0.002	-0.005	-0.005	-0.003	0.000	0.004	0.007
PTB	-0.007	-0.005	-0.006	-0.014	-0.003	0.001	-0.002	-0.008	-0.008	-0.007	-0.003	0.000	0.003
CMI	-0.010	-0.009	-0.010	-0.018	-0.007	-0.003	-0.006	-0.012	-0.012	-0.010	-0.007	-0.004	0.000
GUM	0.001	0.002	0.001	-0.007	0.004	0.008	0.006	-0.001	-0.001	0.001	0.004	0.008	0.011
VMC	0.002	0.004	0.003	-0.005	0.006	0.010	0.007	0.001	0.001	0.002	0.006	0.009	0.012
SMU	-0.001	0.001	-0.001	-0.008	0.003	0.007	0.004	-0.002	-0.002	-0.001	0.003	0.006	0.009
BEV	0.002	0.004	0.002	-0.006	0.006	0.009	0.007	0.001	0.001	0.002	0.006	0.009	0.012
METAS	0.001	0.003	0.001	-0.007	0.004	0.008	0.006	0.000	0.000	0.001	0.004	0.008	0.011
INRIM	-0.003	-0.002	-0.003	-0.011	0.000	0.004	0.001	-0.005	-0.005	-0.004	0.000	0.003	0.006
MIRS	-0.001	0.000	-0.001	-0.009	0.002	0.006	0.003	-0.003	-0.003	-0.001	0.002	0.005	0.008

$U_{\Delta m}$/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT	0.011	0.010	0.009	0.012	0.013	0.012	0.008	0.009	0.012	0.009	0.009	0.009	0.010
LNMC	0.013	0.012	0.012	0.014	0.015	0.014	0.011	0.011	0.014	0.011	0.011	0.011	0.012
DFM	0.010	0.010	0.009	0.012	0.013	0.012	0.008	0.009	0.012	0.009	0.010	0.010	0.012
PTB	0.010	0.009	0.008	0.011	0.013	0.011	0.007	0.008	0.011	0.008	0.009	0.009	0.011
CMI	0.015	0.015	0.015	0.016	0.017	0.017	0.014	0.014	0.017	0.014	0.015	0.015	0.016
GUM	0.012	0.012	0.011	0.014	0.015	0.014	0.010	0.011	0.014	0.011	0.012	0.012	0.013
VMC	0.014	0.013	0.013	0.015	0.016	0.015	0.012	0.013	0.015	0.012	0.014	0.014	0.015
SMU	0.012	0.011	0.011	0.013	0.014	0.013	0.010	0.010	0.013	0.010	0.012	0.012	0.013
BEV	0.011	0.010	0.010	0.012	0.014	0.013	0.009	0.009	0.013	0.009	0.011	0.011	0.012
METAS	0.011	0.011	0.010	0.013	0.014	0.013	0.009	0.010	0.013	0.010	0.011	0.011	0.013
INRIM	0.010	0.009	0.009	0.012	0.013	0.012	0.008	0.009	0.012	0.009	0.010	0.010	0.012
MIRS	0.013	0.012	0.012	0.014	0.015	0.014	0.011	0.012	0.014	0.012	0.013	0.013	0.014

Table 8C: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 20 g

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ	0.010	0.008	0.003	0.007	0.010	-0.001	-0.002	0.001	-0.002	-0.001	0.003	0.001
CEM	0.009	0.006	0.002	0.005	0.009	-0.002	-0.004	-0.001	-0.004	-0.003	0.002	0.000
SMD	0.010	0.008	0.003	0.006	0.010	-0.001	-0.003	0.001	-0.002	-0.001	0.003	0.001
NMi VSL	0.018	0.016	0.011	0.014	0.018	0.007	0.005	0.008	0.006	0.007	0.011	0.009
NML	0.007	0.005	0.000	0.003	0.007	-0.004	-0.006	-0.003	-0.006	-0.004	0.000	-0.002
EIM	0.003	0.001	-0.004	-0.001	0.003	-0.008	-0.010	-0.007	-0.009	-0.008	-0.004	-0.006
UME	0.006	0.003	-0.002	0.002	0.006	-0.006	-0.007	-0.004	-0.007	-0.006	-0.001	-0.003
INM	0.012	0.009	0.005	0.008	0.012	0.001	-0.001	0.002	-0.001	0.000	0.005	0.003
NCM	0.012	0.009	0.005	0.008	0.012	0.001	-0.001	0.002	-0.001	0.000	0.005	0.003
OMH	0.011	0.008	0.003	0.007	0.010	-0.001	-0.002	0.001	-0.002	-0.001	0.004	0.001
JV	0.007	0.005	0.000	0.003	0.007	-0.004	-0.006	-0.003	-0.006	-0.004	0.000	-0.002
SP	0.004	0.001	-0.004	0.000	0.004	-0.008	-0.009	-0.006	-0.009	-0.008	-0.003	-0.005
MIKES	0.001	-0.002	-0.007	-0.003	0.000	-0.011	-0.012	-0.009	-0.012	-0.011	-0.006	-0.008

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ	0.011	0.013	0.010	0.010	0.015	0.012	0.014	0.012	0.011	0.011	0.010	0.013
CEM	0.010	0.012	0.010	0.009	0.015	0.012	0.013	0.011	0.010	0.011	0.009	0.012
SMD	0.009	0.012	0.009	0.008	0.015	0.011	0.013	0.011	0.010	0.010	0.009	0.012
NMi VSL	0.012	0.014	0.012	0.011	0.016	0.014	0.015	0.013	0.012	0.013	0.012	0.014
NML	0.013	0.015	0.013	0.013	0.017	0.015	0.016	0.014	0.014	0.014	0.013	0.015
EIM	0.012	0.014	0.012	0.011	0.017	0.014	0.015	0.013	0.013	0.013	0.012	0.014
UME	0.008	0.011	0.008	0.007	0.014	0.010	0.012	0.010	0.009	0.009	0.008	0.011
INM	0.009	0.011	0.009	0.008	0.014	0.011	0.013	0.010	0.009	0.010	0.009	0.012
NCM	0.012	0.014	0.012	0.011	0.017	0.014	0.015	0.013	0.013	0.013	0.012	0.014
OMH	0.009	0.011	0.009	0.008	0.014	0.011	0.012	0.010	0.009	0.010	0.009	0.012
JV	0.009	0.011	0.010	0.009	0.015	0.012	0.014	0.012	0.011	0.011	0.010	0.013
SP	0.009	0.011	0.010	0.009	0.015	0.012	0.014	0.012	0.011	0.011	0.010	0.013
MIKES	0.010	0.012	0.012	0.011	0.016	0.013	0.015	0.013	0.012	0.013	0.012	0.014

Table 8D: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 20 g

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		-0.003	-0.007	-0.004	0.000	-0.011	-0.013	-0.010	-0.013	-0.012	-0.007	-0.009
LNMC	0.003		-0.005	-0.001	0.002	-0.009	-0.010	-0.007	-0.010	-0.009	-0.005	-0.007
DFM	0.007	0.005		0.003	0.007	-0.004	-0.006	-0.003	-0.006	-0.004	0.000	-0.002
PTB	0.004	0.001	-0.003		0.004	-0.007	-0.009	-0.006	-0.009	-0.008	-0.003	-0.005
CMI	0.000	-0.002	-0.007	-0.004		-0.011	-0.013	-0.010	-0.013	-0.011	-0.007	-0.009
GUM	0.011	0.009	0.004	0.007	0.011		-0.002	0.001	-0.002	0.000	0.004	0.002
VMC	0.013	0.010	0.006	0.009	0.013	0.002		0.003	0.000	0.001	0.006	0.004
SMU	0.010	0.007	0.003	0.006	0.010	-0.001	-0.003		-0.003	-0.002	0.003	0.001
BEV	0.013	0.010	0.006	0.009	0.013	0.002	0.000	0.003		0.001	0.006	0.004
METAS	0.012	0.009	0.004	0.008	0.011	0.000	-0.001	0.002	-0.001		0.005	0.002
INRIM	0.007	0.005	0.000	0.003	0.007	-0.004	-0.006	-0.003	-0.006	-0.005		-0.002
MIRS	0.009	0.007	0.002	0.005	0.009	-0.002	-0.004	-0.001	-0.004	-0.002	0.002	

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		0.010	0.009	0.008	0.015	0.012	0.013	0.011	0.010	0.010	0.009	0.012
LNMC	0.010		0.012	0.011	0.016	0.013	0.015	0.013	0.012	0.013	0.012	0.014
DFM	0.009	0.012		0.007	0.014	0.010	0.012	0.011	0.010	0.010	0.009	0.012
PTB	0.008	0.011	0.007		0.013	0.009	0.011	0.010	0.009	0.009	0.008	0.011
CMI	0.015	0.016	0.014	0.013		0.015	0.016	0.016	0.015	0.015	0.014	0.016
GUM	0.012	0.013	0.010	0.009	0.015		0.014	0.013	0.012	0.012	0.011	0.014
VMC	0.013	0.015	0.012	0.011	0.016	0.014		0.014	0.013	0.014	0.013	0.015
SMU	0.011	0.013	0.011	0.010	0.016	0.013	0.014		0.009	0.010	0.009	0.012
BEV	0.010	0.012	0.010	0.009	0.015	0.012	0.013	0.009		0.009	0.008	0.011
METAS	0.010	0.013	0.010	0.009	0.015	0.012	0.014	0.010	0.009		0.008	0.011
INRIM	0.009	0.012	0.009	0.008	0.014	0.011	0.013	0.009	0.008	0.008		0.010
MIRS	0.012	0.014	0.012	0.011	0.016	0.014	0.015	0.012	0.011	0.011	0.010	

Table 9A: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 2 g

Δm/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ		-0.000 2	0.000 1	-0.000 3	-0.001 5	-0.001 1	-0.001 7	-0.003 5	-0.002 0	-0.002 3	0.000 2	-0.002 5	-0.001 0
CEM	0.000 2		0.000 3	-0.000 1	-0.001 3	-0.000 9	-0.001 5	-0.003 3	-0.001 8	-0.002 0	0.000 4	-0.002 3	-0.000 8
SMD	-0.000 1	-0.000 3		-0.000 4	-0.001 6	-0.001 2	-0.001 8	-0.003 6	-0.002 1	-0.002 4	0.000 1	-0.002 6	-0.001 1
NMi VSL	0.000 3	0.000 1	0.000 4		-0.001 2	-0.000 8	-0.001 4	-0.003 2	-0.001 7	-0.002 0	0.000 5	-0.002 2	-0.000 7
NML	0.001 5	0.001 3	0.001 6	0.001 2		0.000 4	-0.000 2	-0.002 0	-0.000 5	-0.000 8	0.001 7	-0.001 0	0.000 5
EIM	0.001 1	0.000 9	0.001 2	0.000 8	-0.000 4		-0.000 6	-0.002 4	-0.000 9	-0.001 2	0.001 3	-0.001 4	0.000 1
UME	0.001 7	0.001 5	0.001 8	0.001 4	0.000 2	0.000 6		-0.001 8	-0.000 3	-0.000 6	0.001 9	-0.000 8	0.000 7
INM	0.003 5	0.003 3	0.003 6	0.003 2	0.002 0	0.002 4	0.001 8		0.001 5	0.001 3	0.003 7	0.001 0	0.002 5
NCM	0.002 0	0.001 8	0.002 1	0.001 7	0.000 5	0.000 9	0.000 3	-0.001 5		-0.000 3	0.002 2	-0.000 5	0.001 0
OMH	0.002 3	0.002 0	0.002 4	0.002 0	0.000 8	0.001 2	0.000 6	-0.001 3	0.000 3		0.002 5	-0.000 3	0.001 3
JV	-0.000 2	-0.000 4	-0.000 1	-0.000 5	-0.001 7	-0.001 3	-0.001 9	-0.003 7	-0.002 2	-0.002 5		-0.002 7	-0.001 2
SP	0.002 5	0.002 3	0.002 6	0.002 2	0.001 0	0.001 4	0.000 8	-0.001 0	0.000 5	0.000 3	0.002 7		0.001 5
MIKES	0.001 0	0.000 8	0.001 1	0.000 7	-0.000 5	-0.000 1	-0.000 7	-0.002 5	-0.001 0	-0.001 3	0.001 2	-0.001 5	

$U_{\Delta m}$/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ		0.005 7	0.005 7	0.006 9	0.008 2	0.009 8	0.006 9	0.007 5	0.009 3	0.007 0	0.007 7	0.008 1	0.007 5
CEM	0.005 7		0.004 5	0.005 9	0.007 4	0.009 2	0.006 0	0.006 6	0.008 6	0.006 0	0.006 8	0.007 3	0.006 6
SMD	0.005 7	0.004 5		0.005 9	0.007 4	0.009 2	0.006 0	0.006 7	0.008 6	0.006 1	0.006 8	0.007 4	0.006 7
NMi VSL	0.006 9	0.005 9	0.005 9		0.008 3	0.009 9	0.007 1	0.007 7	0.009 4	0.007 1	0.007 8	0.008 3	0.007 6
NML	0.008 2	0.007 4	0.007 4	0.008 3		0.010 9	0.008 4	0.008 9	0.010 4	0.008 4	0.009 0	0.009 4	0.008 9
EIM	0.009 8	0.009 2	0.009 2	0.009 9	0.010 9		0.008 1	0.008 6	0.010 2	0.008 2	0.009 6	0.010 0	0.009 5
UME	0.006 9	0.006 0	0.006 0	0.007 1	0.008 4	0.008 1		0.005 1	0.007 4	0.004 3	0.006 7	0.007 2	0.006 5
INM	0.007 5	0.006 6	0.006 7	0.007 7	0.008 9	0.008 6	0.005 1		0.008 0	0.005 1	0.007 3	0.007 8	0.007 1
NCM	0.009 3	0.008 6	0.008 6	0.009 4	0.010 4	0.010 2	0.007 4	0.008 0		0.007 5	0.009 1	0.009 5	0.008 9
OMH	0.007 0	0.006 0	0.006 1	0.007 1	0.008 4	0.008 2	0.004 3	0.005 1	0.007 5		0.006 7	0.007 2	0.006 5
JV	0.007 7	0.006 8	0.006 8	0.007 8	0.009 0	0.009 6	0.006 7	0.007 3	0.009 1	0.006 7		0.006 7	0.006 0
SP	0.008 1	0.007 3	0.007 4	0.008 3	0.009 4	0.010 0	0.007 2	0.007 8	0.009 5	0.007 2	0.006 7		0.006 5
MIKES	0.007 5	0.006 6	0.006 7	0.007 6	0.008 9	0.009 5	0.006 5	0.007 1	0.008 9	0.006 5	0.006 0	0.006 5	

Table 9B: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 2 g

Δm/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT	0.000 1	-0.000 1	0.000 2	-0.000 2	-0.001 4	-0.001 0	-0.001 6	-0.003 4	-0.001 9	-0.002 2	0.000 3	-0.002 4	-0.000 9
LNMC	-0.002 8	-0.003 0	-0.002 7	-0.003 1	-0.004 3	-0.003 9	-0.004 5	-0.006 3	-0.004 8	-0.005 1	-0.002 6	-0.005 3	-0.003 8
DFM	0.001 7	0.001 5	0.001 8	0.001 4	0.000 2	0.000 6	0.000 0	-0.001 8	-0.000 3	-0.000 6	0.001 9	-0.000 8	0.000 7
PTB	0.001 2	0.001 0	0.001 3	0.000 9	-0.000 3	0.000 1	-0.000 5	-0.002 3	-0.000 8	-0.001 0	0.001 4	-0.001 3	0.000 2
CMI	0.001 0	0.000 8	0.001 1	0.000 7	-0.000 5	-0.000 1	-0.000 7	-0.002 5	-0.001 0	-0.001 3	0.001 2	-0.001 5	0.000 0
GUM	0.004 0	0.003 8	0.004 1	0.003 7	0.002 5	0.002 9	0.002 3	0.000 5	0.002 0	0.001 8	0.004 2	0.001 5	0.003 0
VMC	0.011 0	0.010 8	0.011 1	0.010 7	0.009 5	0.009 9	0.009 3	0.007 5	0.009 0	0.008 8	0.011 2	0.008 5	0.010 0
SMU	0.002 0	0.001 8	0.002 1	0.001 7	0.000 5	0.000 9	0.000 3	-0.001 5	0.000 0	-0.000 3	0.002 2	-0.000 5	0.001 0
BEV	0.002 5	0.002 3	0.002 6	0.002 2	0.001 0	0.001 4	0.000 8	-0.001 0	0.000 5	0.000 3	0.002 7	0.000 0	0.001 5
METAS	0.001 1	0.000 9	0.001 2	0.000 8	-0.000 4	0.000 0	-0.000 6	-0.002 4	-0.000 9	-0.001 2	0.001 3	-0.001 4	0.000 1
INRIM	0.001 9	0.001 7	0.002 0	0.001 6	0.000 4	0.000 8	0.000 2	-0.001 6	-0.000 1	-0.000 4	0.002 1	-0.000 6	0.000 9
MIRS	0.001 6	0.001 4	0.001 7	0.001 3	0.000 1	0.000 5	-0.000 1	-0.001 9	-0.000 4	-0.000 7	0.001 8	-0.000 9	0.000 6

$U_{\Delta m}$/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT	0.007 2	0.006 3	0.006 4	0.007 4	0.008 6	0.009 3	0.006 2	0.006 8	0.008 7	0.006 2	0.005 6	0.006 2	0.005 4
LNMC	0.008 7	0.007 9	0.008 0	0.008 8	0.009 9	0.010 5	0.007 8	0.008 3	0.010 0	0.007 9	0.007 4	0.007 9	0.007 2
DFM	0.007 2	0.006 2	0.006 3	0.007 3	0.008 6	0.009 3	0.006 1	0.006 8	0.008 7	0.006 1	0.006 9	0.007 4	0.006 7
PTB	0.006 9	0.005 9	0.006 0	0.007 1	0.008 4	0.009 0	0.005 8	0.006 5	0.008 4	0.005 8	0.006 6	0.007 2	0.006 5
CMI	0.009 1	0.008 4	0.008 5	0.009 3	0.010 3	0.010 8	0.008 3	0.008 8	0.010 3	0.008 4	0.008 9	0.009 3	0.008 8
GUM	0.007 2	0.006 2	0.006 3	0.007 3	0.008 6	0.009 3	0.006 1	0.006 8	0.008 7	0.006 1	0.006 9	0.007 4	0.006 7
VMC	0.019 3	0.018 9	0.019 0	0.019 3	0.019 8	0.020 1	0.018 9	0.019 1	0.019 9	0.018 9	0.019 2	0.019 4	0.019 1
SMU	0.007 7	0.006 8	0.006 8	0.007 8	0.009 0	0.009 6	0.006 7	0.007 3	0.009 1	0.006 7	0.007 4	0.007 9	0.007 3
BEV	0.007 1	0.006 2	0.006 3	0.007 3	0.008 6	0.009 2	0.006 1	0.006 7	0.008 6	0.006 1	0.006 9	0.007 4	0.006 7
METAS	0.007 2	0.006 2	0.006 3	0.007 3	0.008 6	0.009 3	0.006 1	0.006 8	0.008 7	0.006 1	0.006 9	0.007 4	0.006 7
INRIM	0.007 0	0.006 1	0.006 1	0.007 2	0.008 4	0.009 1	0.005 9	0.006 6	0.008 5	0.006 0	0.006 7	0.007 3	0.006 6
MIRS	0.007 9	0.007 1	0.007 2	0.008 1	0.009 2	0.009 9	0.007 0	0.007 6	0.009 3	0.007 0	0.007 7	0.008 2	0.007 6

Table 9C: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 2 g

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ	-0.000 1	0.002 8	-0.001 7	-0.001 2	-0.001 0	-0.004 0	-0.011 0	-0.002 0	-0.002 5	-0.001 1	-0.001 9	-0.001 6
CEM	0.000 1	0.003 0	-0.001 5	-0.001 0	-0.000 8	-0.003 8	-0.010 8	-0.001 8	-0.002 3	-0.000 9	-0.001 7	-0.001 4
SMD	-0.000 2	0.002 7	-0.001 8	-0.001 3	-0.001 1	-0.004 1	-0.011 1	-0.002 1	-0.002 6	-0.001 2	-0.002 0	-0.001 7
NMi VSL	0.000 2	0.003 1	-0.001 4	-0.000 9	-0.000 7	-0.003 7	-0.010 7	-0.001 7	-0.002 2	-0.000 8	-0.001 6	-0.001 3
NML	0.001 4	0.004 3	-0.000 2	0.000 3	0.000 5	-0.002 5	-0.009 5	-0.000 5	-0.001 0	0.000 4	-0.000 4	-0.000 1
EIM	0.001 0	0.003 9	-0.000 6	-0.000 1	0.000 1	-0.002 9	-0.009 9	-0.000 9	-0.001 4	0.000 0	-0.000 8	-0.000 5
UME	0.001 6	0.004 5	0.000 0	0.000 5	0.000 7	-0.002 3	-0.009 3	-0.000 3	-0.000 8	0.000 6	-0.000 2	0.000 1
INM	0.003 4	0.006 3	0.001 8	0.002 3	0.002 5	-0.000 5	-0.007 5	0.001 5	0.001 0	0.002 4	0.001 6	0.001 9
NCM	0.001 9	0.004 8	0.000 3	0.000 8	0.001 0	-0.002 0	-0.009 0	0.000 0	-0.000 5	0.000 9	0.000 1	0.000 4
OMH	0.002 2	0.005 1	0.000 6	0.001 0	0.001 3	-0.001 8	-0.008 8	0.000 3	-0.000 3	0.001 2	0.000 4	0.000 7
JV	-0.000 3	0.002 6	-0.001 9	-0.001 4	-0.001 2	-0.004 2	-0.011 2	-0.002 2	-0.002 7	-0.001 3	-0.002 1	-0.001 8
SP	0.002 4	0.005 3	0.000 8	0.001 3	0.001 5	-0.001 5	-0.008 5	0.000 5	0.000 0	0.001 4	0.000 6	0.000 9
MIKES	0.000 9	0.003 8	-0.000 7	-0.000 2	0.000 0	-0.003 0	-0.010 0	-0.001 0	-0.001 5	-0.000 1	-0.000 9	-0.000 6

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ	0.007 2	0.008 7	0.007 2	0.006 9	0.009 1	0.007 2	0.019 3	0.007 7	0.007 1	0.007 2	0.007 0	0.007 9
CEM	0.006 3	0.007 9	0.006 2	0.005 9	0.008 4	0.006 2	0.018 9	0.006 8	0.006 2	0.006 2	0.006 1	0.007 1
SMD	0.006 4	0.008 0	0.006 3	0.006 0	0.008 5	0.006 3	0.019 0	0.006 8	0.006 3	0.006 3	0.006 1	0.007 2
NMi VSL	0.007 4	0.008 8	0.007 3	0.007 1	0.009 3	0.007 3	0.019 3	0.007 8	0.007 3	0.007 3	0.007 2	0.008 1
NML	0.008 6	0.009 9	0.008 6	0.008 4	0.010 3	0.008 6	0.019 8	0.009 0	0.008 6	0.008 6	0.008 4	0.009 2
EIM	0.009 3	0.010 5	0.009 3	0.009 0	0.010 8	0.009 3	0.020 1	0.009 6	0.009 2	0.009 3	0.009 1	0.009 9
UME	0.006 2	0.007 8	0.006 1	0.005 8	0.008 3	0.006 1	0.018 9	0.006 7	0.006 1	0.006 1	0.005 9	0.007 0
INM	0.006 8	0.008 3	0.006 8	0.006 5	0.008 8	0.006 8	0.019 1	0.007 3	0.006 7	0.006 8	0.006 6	0.007 6
NCM	0.008 7	0.010 0	0.008 7	0.008 4	0.010 3	0.008 7	0.019 9	0.009 1	0.008 6	0.008 7	0.008 5	0.009 3
OMH	0.006 2	0.007 9	0.006 1	0.005 8	0.008 4	0.006 1	0.018 9	0.006 7	0.006 1	0.006 1	0.006 0	0.007 0
JV	0.005 6	0.007 4	0.006 9	0.006 6	0.008 9	0.006 9	0.019 2	0.007 4	0.006 9	0.006 9	0.006 7	0.007 7
SP	0.006 2	0.007 9	0.007 4	0.007 2	0.009 3	0.007 4	0.019 4	0.007 9	0.007 4	0.007 4	0.007 3	0.008 2
MIKES	0.005 4	0.007 2	0.006 7	0.006 5	0.008 8	0.006 7	0.019 1	0.007 3	0.006 7	0.006 7	0.006 6	0.007 6

Table 9D: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 2 g

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		0.002 9	-0.001 6	-0.001 1	-0.000 9	-0.003 9	-0.010 9	-0.001 9	-0.002 4	-0.001 0	-0.001 8	-0.001 5
LNMC	-0.002 9		-0.004 5	-0.004 0	-0.003 8	-0.006 8	-0.013 8	-0.004 8	-0.005 3	-0.003 9	-0.004 7	-0.004 4
DFM	0.001 6	0.004 5		0.000 5	0.000 7	-0.002 3	-0.009 3	-0.000 3	-0.000 8	0.000 6	-0.000 2	0.000 1
PTB	0.001 1	0.004 0	-0.000 5		0.000 2	-0.002 8	-0.009 8	-0.000 8	-0.001 3	0.000 1	-0.000 7	-0.000 4
CMI	0.000 9	0.003 8	-0.000 7	-0.000 2		-0.003 0	-0.010 0	-0.001 0	-0.001 5	-0.000 1	-0.000 9	-0.000 6
GUM	0.003 9	0.006 8	0.002 3	0.002 8	0.003 0		-0.007 0	0.002 0	0.001 5	0.002 9	0.002 1	0.002 4
VMC	0.010 9	0.013 8	0.009 3	0.009 8	0.010 0	0.007 0		0.009 0	0.008 5	0.009 9	0.009 1	0.009 4
SMU	0.001 9	0.004 8	0.000 3	0.000 8	0.001 0	-0.002 0	-0.009 0		-0.000 5	0.000 9	0.000 1	0.000 4
BEV	0.002 4	0.005 3	0.000 8	0.001 3	0.001 5	-0.001 5	-0.008 5	0.000 5		0.001 4	0.000 6	0.000 9
METAS	0.001 0	0.003 9	-0.000 6	-0.000 1	0.000 1	-0.002 9	-0.009 9	-0.000 9	-0.001 4		-0.000 8	-0.000 5
INRIM	0.001 8	0.004 7	0.000 2	0.000 7	0.000 9	-0.002 1	-0.009 1	-0.000 1	-0.000 6	0.000 8		0.000 3
MIRS	0.001 5	0.004 4	-0.000 1	0.000 4	0.000 6	-0.002 4	-0.009 4	-0.000 4	-0.000 9	0.000 5	-0.000 3	

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		0.007 0	0.006 5	0.006 2	0.008 6	0.006 5	0.019 0	0.007 0	0.006 4	0.006 4	0.006 3	0.007 3
LNMC	0.007 0		0.008 0	0.007 8	0.009 8	0.008 0	0.019 6	0.008 5	0.008 0	0.008 0	0.007 9	0.008 7
DFM	0.006 5	0.008 0		0.004 5	0.007 5	0.004 9	0.018 6	0.006 9	0.006 4	0.006 4	0.006 2	0.007 2
PTB	0.006 2	0.007 8	0.004 5		0.007 2	0.004 5	0.018 5	0.006 6	0.006 0	0.006 1	0.005 9	0.007 0
CMI	0.008 6	0.009 8	0.007 5	0.007 2		0.007 5	0.019 4	0.008 9	0.008 5	0.008 5	0.008 4	0.009 2
GUM	0.006 5	0.008 0	0.004 9	0.004 5	0.007 5		0.018 6	0.006 9	0.006 4	0.006 4	0.006 2	0.007 2
VMC	0.019 0	0.019 6	0.018 6	0.018 5	0.019 4	0.018 6		0.019 2	0.019 0	0.019 0	0.018 9	0.019 3
SMU	0.007 0	0.008 5	0.006 9	0.006 6	0.008 9	0.006 9	0.019 2		0.005 6	0.005 6	0.005 4	0.006 6
BEV	0.006 4	0.008 0	0.006 4	0.006 0	0.008 5	0.006 4	0.019 0	0.005 6		0.004 9	0.004 7	0.006 0
METAS	0.006 4	0.008 0	0.006 4	0.006 1	0.008 5	0.006 4	0.019 0	0.005 6	0.004 9		0.004 7	0.006 0
INRIM	0.006 3	0.007 9	0.006 2	0.005 9	0.008 4	0.006 2	0.018 9	0.005 4	0.004 7	0.004 7		0.002 9
MIRS	0.007 3	0.008 7	0.007 2	0.007 0	0.009 2	0.007 2	0.019 3	0.006 6	0.006 0	0.006 0	0.005 8	

Table 10A: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 100 mg

Δm/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ		0.000 1	-0.000 1	-0.000 5	0.000 0	0.001 3	0.000 9	0.000 4	-0.000 6	-0.001 0	-0.000 7	-0.000 9	0.000 1
CEM	-0.000 1		-0.000 2	-0.000 6	-0.000 1	0.001 1	0.000 7	0.000 2	-0.000 7	-0.001 2	-0.000 9	-0.001 0	-0.000 1
SMD	0.000 1	0.000 2		-0.000 5	0.000 1	0.001 3	0.000 9	0.000 4	-0.000 5	-0.001 0	-0.000 7	-0.000 8	0.000 1
NMi VSL	0.000 5	0.000 6	0.000 5		0.000 5	0.001 8	0.001 4	0.000 9	-0.000 1	-0.000 5	-0.000 2	-0.000 4	0.000 6
NML	0.000 0	0.000 1	-0.000 1	-0.000 5		0.001 3	0.000 9	0.000 4	-0.000 6	-0.001 0	-0.000 7	-0.000 9	0.000 1
EIM	-0.001 3	-0.001 1	-0.001 3	-0.001 8	-0.001 3		-0.000 4	-0.000 9	-0.001 8	-0.002 3	-0.002 0	-0.002 1	-0.001 2
UME	-0.000 9	-0.000 7	-0.000 9	-0.001 4	-0.000 9	0.000 4		-0.000 5	-0.001 4	-0.001 9	-0.001 6	-0.001 7	-0.000 8
INM	-0.000 4	-0.000 2	-0.000 4	-0.000 9	-0.000 4	0.000 9	0.000 5		-0.000 9	-0.001 4	-0.001 1	-0.001 2	-0.000 3
NCM	0.000 6	0.000 7	0.000 5	0.000 1	0.000 6	0.001 8	0.001 4	0.000 9		-0.000 5	-0.000 2	-0.000 3	0.000 6
OMH	0.001 0	0.001 2	0.001 0	0.000 5	0.001 0	0.002 3	0.001 9	0.001 4	0.000 5		0.000 3	0.000 2	0.001 1
JV	0.000 7	0.000 9	0.000 7	0.000 2	0.000 7	0.002 0	0.001 6	0.001 1	0.000 2	-0.000 3		-0.000 1	0.000 8
SP	0.000 9	0.001 0	0.000 8	0.000 4	0.000 9	0.002 1	0.001 7	0.001 2	0.000 3	-0.000 2	0.000 1		0.000 9
MIKES	-0.000 1	0.000 1	-0.000 1	-0.000 6	-0.000 1	0.001 2	0.000 8	0.000 3	-0.000 6	-0.001 1	-0.000 8	-0.000 9	

$U_{\Delta m}$/mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
IPQ		0.001 7	0.001 8	0.002 3	0.002 6	0.002 7	0.002 0	0.002 6	0.003 9	0.002 0	0.002 3	0.002 2	0.002 1
CEM	0.001 7		0.001 1	0.001 8	0.002 2	0.002 3	0.001 4	0.002 3	0.003 7	0.001 4	0.001 8	0.001 8	0.001 6
SMD	0.001 8	0.001 1		0.001 9	0.002 3	0.002 4	0.001 5	0.002 3	0.003 7	0.001 5	0.001 9	0.001 8	0.001 7
NMi VSL	0.002 3	0.001 8	0.001 9		0.002 7	0.002 8	0.002 1	0.002 8	0.004 0	0.002 1	0.002 4	0.002 4	0.002 3
NML	0.002 6	0.002 2	0.002 3	0.002 7		0.003 0	0.002 4	0.003 0	0.004 2	0.002 4	0.002 7	0.002 6	0.002 6
EIM	0.002 7	0.002 3	0.002 4	0.002 8	0.003 0		0.002 1	0.002 8	0.004 0	0.002 1	0.002 6	0.002 6	0.002 5
UME	0.002 0	0.001 4	0.001 5	0.002 1	0.002 4	0.002 1		0.002 1	0.003 6	0.001 1	0.001 9	0.001 8	0.001 7
INM	0.002 6	0.002 3	0.002 3	0.002 8	0.003 0	0.002 8	0.002 1		0.004 0	0.002 1	0.002 6	0.002 6	0.002 5
NCM	0.003 9	0.003 7	0.003 7	0.004 0	0.004 2	0.004 0	0.003 6	0.004 0		0.003 6	0.003 9	0.003 9	0.003 8
OMH	0.002 0	0.001 4	0.001 5	0.002 1	0.002 4	0.002 1	0.001 1	0.002 1	0.003 6		0.001 9	0.001 8	0.001 7
JV	0.002 3	0.001 8	0.001 9	0.002 4	0.002 7	0.002 6	0.001 9	0.002 6	0.003 9	0.001 9		0.002 0	0.001 9
SP	0.002 2	0.001 8	0.001 8	0.002 4	0.002 6	0.002 6	0.001 8	0.002 6	0.003 9	0.001 8	0.002 0		0.001 8
MIKES	0.002 1	0.001 6	0.001 7	0.002 3	0.002 6	0.002 5	0.001 7	0.002 5	0.003 8	0.001 7	0.001 9	0.001 8	

Table 10B: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 100 mg

Δm /mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT	-0.000 1	0.000 1	-0.000 1	-0.000 6	-0.000 1	0.001 2	0.000 8	0.000 3	-0.000 6	-0.001 1	-0.000 8	-0.000 9	0.000 0
LNMC	-0.000 6	-0.000 4	-0.000 6	-0.001 1	-0.000 6	0.000 7	0.000 3	-0.000 2	-0.001 1	-0.001 6	-0.001 3	-0.001 4	-0.000 5
DFM	0.000 4	0.000 5	0.000 4	-0.000 1	0.000 4	0.001 7	0.001 3	0.000 8	-0.000 2	-0.000 6	-0.000 3	-0.000 5	0.000 5
PTB	0.000 7	0.000 8	0.000 7	0.000 2	0.000 7	0.002 0	0.001 6	0.001 1	0.000 2	-0.000 3	0.000 0	-0.000 2	0.000 8
CMI	0.001 2	0.001 3	0.001 2	0.000 7	0.001 2	0.002 5	0.002 1	0.001 6	0.000 7	0.000 2	0.000 5	0.000 4	0.001 3
GUM	-0.000 3	-0.000 2	-0.000 4	-0.000 8	-0.000 3	0.001 0	0.000 6	0.000 0	-0.000 9	-0.001 3	-0.001 0	-0.001 2	-0.000 3
VMC	-0.002 2	-0.002 1	-0.002 3	-0.002 7	-0.002 2	-0.001 0	-0.001 4	-0.001 9	-0.002 8	-0.003 2	-0.002 9	-0.003 1	-0.002 2
SMU	-0.002 4	-0.002 2	-0.002 4	-0.002 9	-0.002 4	-0.001 1	-0.001 5	-0.002 0	-0.002 9	-0.003 4	-0.003 1	-0.003 2	-0.002 3
BEV	-0.000 3	-0.000 1	-0.000 3	-0.000 8	-0.000 3	0.001 0	0.000 6	0.000 1	-0.000 8	-0.001 3	-0.001 0	-0.001 1	-0.000 2
METAS	0.000 0	0.000 1	-0.000 1	-0.000 5	0.000 0	0.001 2	0.000 8	0.000 3	-0.000 6	-0.001 1	-0.000 8	-0.000 9	0.000 0
INRIM	0.000 2	0.000 3	0.000 1	-0.000 4	0.000 2	0.001 4	0.001 0	0.000 5	-0.000 4	-0.000 9	-0.000 6	-0.000 7	0.000 2
MIRS	0.000 1	0.000 2	0.000 0	-0.000 5	0.000 1	0.001 3	0.000 9	0.000 4	-0.000 5	-0.001 0	-0.000 7	-0.000 8	0.000 1

$U_{\Delta m}$ /mg	IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
METROSERT	0.002 2	0.001 7	0.001 8	0.002 3	0.002 6	0.002 6	0.001 8	0.002 5	0.003 8	0.001 8	0.002 0	0.001 9	0.001 8
LNMC	0.002 3	0.001 9	0.002 0	0.002 5	0.002 7	0.002 7	0.002 0	0.002 7	0.003 9	0.002 0	0.002 1	0.002 1	0.001 9
DFM	0.002 0	0.001 5	0.001 6	0.002 2	0.002 5	0.002 4	0.001 6	0.002 4	0.003 7	0.001 6	0.002 0	0.001 9	0.001 8
PTB	0.001 9	0.001 3	0.001 4	0.002 0	0.002 3	0.002 3	0.001 4	0.002 2	0.003 7	0.001 4	0.001 8	0.001 7	0.001 6
CMI	0.003 0	0.002 7	0.002 8	0.003 1	0.003 3	0.003 3	0.002 7	0.003 3	0.004 4	0.002 8	0.003 0	0.002 9	0.002 9
GUM	0.002 0	0.001 5	0.001 6	0.002 2	0.002 5	0.002 4	0.001 6	0.002 4	0.003 7	0.001 6	0.002 0	0.001 9	0.001 8
VMC	0.003 5	0.003 2	0.003 3	0.003 6	0.003 8	0.003 8	0.003 3	0.003 7	0.004 7	0.003 3	0.003 5	0.003 5	0.003 4
SMU	0.002 3	0.001 9	0.001 9	0.002 4	0.002 7	0.002 7	0.001 9	0.002 6	0.003 9	0.001 9	0.002 3	0.002 2	0.002 1
BEV	0.001 9	0.001 4	0.001 5	0.002 1	0.002 4	0.002 3	0.001 5	0.002 3	0.003 7	0.001 5	0.001 9	0.001 8	0.001 7
METAS	0.001 9	0.001 3	0.001 4	0.002 1	0.002 4	0.002 3	0.001 4	0.002 3	0.003 7	0.001 4	0.001 9	0.001 8	0.001 7
INRIM	0.001 9	0.001 4	0.001 5	0.002 1	0.002 4	0.002 3	0.001 5	0.002 3	0.003 7	0.001 5	0.001 9	0.001 8	0.001 7
MIRS	0.002 4	0.001 9	0.002 0	0.002 5	0.002 8	0.002 7	0.002 0	0.002 7	0.003 9	0.002 0	0.002 3	0.002 3	0.002 2

Table 10C: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 100 mg

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ	0.000 1	0.000 6	-0.000 4	-0.000 7	-0.001 2	0.000 3	0.002 2	0.002 4	0.000 3	0.000 0	-0.000 2	-0.000 1
CEM	-0.000 1	0.000 4	-0.000 5	-0.000 8	-0.001 3	0.000 2	0.002 1	0.002 2	0.000 1	-0.000 1	-0.000 3	-0.000 2
SMD	0.000 1	0.000 6	-0.000 4	-0.000 7	-0.001 2	0.000 4	0.002 3	0.002 4	0.000 3	0.000 1	-0.000 1	0.000 0
NMi VSL	0.000 6	0.001 1	0.000 1	-0.000 2	-0.000 7	0.000 8	0.002 7	0.002 9	0.000 8	0.000 5	0.000 4	0.000 5
NML	0.000 1	0.000 6	-0.000 4	-0.000 7	-0.001 2	0.000 3	0.002 2	0.002 4	0.000 3	0.000 0	-0.000 2	-0.000 1
EIM	-0.001 2	-0.000 7	-0.001 7	-0.002 0	-0.002 5	-0.001 0	0.001 0	0.001 1	-0.001 0	-0.001 2	-0.001 4	-0.001 3
UME	-0.000 8	-0.000 3	-0.001 3	-0.001 6	-0.002 1	-0.000 6	0.001 4	0.001 5	-0.000 6	-0.000 8	-0.001 0	-0.000 9
INM	-0.000 3	0.000 2	-0.000 8	-0.001 1	-0.001 6	0.000 0	0.001 9	0.002 0	-0.000 1	-0.000 3	-0.000 5	-0.000 4
NCM	0.000 6	0.001 1	0.000 2	-0.000 2	-0.000 7	0.000 9	0.002 8	0.002 9	0.000 8	0.000 6	0.000 4	0.000 5
OMH	0.001 1	0.001 6	0.000 6	0.000 3	-0.000 2	0.001 3	0.003 2	0.003 4	0.001 3	0.001 1	0.000 9	0.001 0
JV	0.000 8	0.001 3	0.000 3	0.000 0	-0.000 5	0.001 0	0.002 9	0.003 1	0.001 0	0.000 8	0.000 6	0.000 7
SP	0.000 9	0.001 4	0.000 5	0.000 2	-0.000 4	0.001 2	0.003 1	0.003 2	0.001 1	0.000 9	0.000 7	0.000 8
MIKES	0.000 0	0.000 5	-0.000 5	-0.000 8	-0.001 3	0.000 3	0.002 2	0.002 3	0.000 2	0.000 0	-0.000 2	-0.000 1

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
IPQ	0.002 2	0.002 3	0.002 0	0.001 9	0.003 0	0.002 0	0.003 5	0.002 3	0.001 9	0.001 9	0.001 9	0.002 4
CEM	0.001 7	0.001 9	0.001 5	0.001 3	0.002 7	0.001 5	0.003 2	0.001 9	0.001 4	0.001 3	0.001 4	0.001 9
SMD	0.001 8	0.002 0	0.001 6	0.001 4	0.002 8	0.001 6	0.003 3	0.001 9	0.001 5	0.001 4	0.001 5	0.002 0
NMi VSL	0.002 3	0.002 5	0.002 2	0.002 0	0.003 1	0.002 2	0.003 6	0.002 4	0.002 1	0.002 1	0.002 1	0.002 5
NML	0.002 6	0.002 7	0.002 5	0.002 3	0.003 3	0.002 5	0.003 8	0.002 7	0.002 4	0.002 4	0.002 4	0.002 8
EIM	0.002 6	0.002 7	0.002 4	0.002 3	0.003 3	0.002 4	0.003 8	0.002 7	0.002 3	0.002 3	0.002 3	0.002 7
UME	0.001 8	0.002 0	0.001 6	0.001 4	0.002 7	0.001 6	0.003 3	0.001 9	0.001 5	0.001 4	0.001 5	0.002 0
INM	0.002 5	0.002 7	0.002 4	0.002 2	0.003 3	0.002 4	0.003 7	0.002 6	0.002 3	0.002 3	0.002 3	0.002 7
NCM	0.003 8	0.003 9	0.003 7	0.003 7	0.004 4	0.003 7	0.004 7	0.003 9	0.003 7	0.003 7	0.003 7	0.003 9
OMH	0.001 8	0.002 0	0.001 6	0.001 4	0.002 8	0.001 6	0.003 3	0.001 9	0.001 5	0.001 4	0.001 5	0.002 0
JV	0.002 0	0.002 1	0.002 0	0.001 8	0.003 0	0.002 0	0.003 5	0.002 3	0.001 9	0.001 9	0.001 9	0.002 3
SP	0.001 9	0.002 1	0.001 9	0.001 7	0.002 9	0.001 9	0.003 5	0.002 2	0.001 8	0.001 8	0.001 8	0.002 3
MIKES	0.001 8	0.001 9	0.001 8	0.001 6	0.002 9	0.001 8	0.003 4	0.002 1	0.001 7	0.001 7	0.001 7	0.002 2

Table 10D: Differences Δm (top) in assigned values between laboratory A (left column) and laboratory B (top row) and expanded uncertainties at k=2 (bottom) for 100 mg

Δm /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		0.000 5	-0.000 5	-0.000 8	-0.001 3	0.000 2	0.002 1	0.002 3	0.000 2	0.000 0	-0.000 2	-0.000 1
LNMC	-0.000 5		-0.001 0	-0.001 3	-0.001 8	-0.000 3	0.001 7	0.001 8	-0.000 3	-0.000 5	-0.000 7	-0.000 6
DFM	0.000 5	0.001 0		-0.000 3	-0.000 8	0.000 7	0.002 6	0.002 8	0.000 7	0.000 4	0.000 3	0.000 4
PTB	0.000 8	0.001 3	0.000 3		-0.000 5	0.001 0	0.002 9	0.003 1	0.001 0	0.000 7	0.000 6	0.000 7
CMI	0.001 3	0.001 8	0.000 8	0.000 5		0.001 5	0.003 4	0.003 6	0.001 5	0.001 2	0.001 1	0.001 2
GUM	-0.000 2	0.000 3	-0.000 7	-0.001 0	-0.001 5		0.001 9	0.002 1	0.000 0	-0.000 3	-0.000 5	-0.000 4
VMC	-0.002 1	-0.001 7	-0.002 6	-0.002 9	-0.003 4	-0.001 9		0.000 2	-0.002 0	-0.002 2	-0.002 4	-0.002 3
SMU	-0.002 3	-0.001 8	-0.002 8	-0.003 1	-0.003 6	-0.002 1	-0.000 2		-0.002 1	-0.002 3	-0.002 5	-0.002 4
BEV	-0.000 2	0.000 3	-0.000 7	-0.001 0	-0.001 5	0.000 0	0.002 0	0.002 1		-0.000 2	-0.000 4	-0.000 3
METAS	0.000 0	0.000 5	-0.000 4	-0.000 7	-0.001 2	0.000 3	0.002 2	0.002 3	0.000 2		-0.000 2	-0.000 1
INRIM	0.000 2	0.000 7	-0.000 3	-0.000 6	-0.001 1	0.000 5	0.002 4	0.002 5	0.000 4	0.000 2		0.000 1
MIRS	0.000 1	0.000 6	-0.000 4	-0.000 7	-0.001 2	0.000 4	0.002 3	0.002 4	0.000 3	0.000 1	-0.000 1	

$U_{\Delta m}$ /mg	METROSERT	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
METROSERT		0.002 0	0.001 9	0.001 7	0.002 9	0.001 9	0.003 4	0.002 2	0.001 8	0.001 8	0.001 8	0.002 3
LNMC	0.002 0		0.002 0	0.001 9	0.003 0	0.002 0	0.003 5	0.002 3	0.001 9	0.001 9	0.001 9	0.002 4
DFM	0.001 9	0.002 0		0.001 2	0.002 7	0.001 4	0.003 2	0.002 0	0.001 6	0.001 5	0.001 6	0.002 1
PTB	0.001 7	0.001 9	0.001 2		0.002 6	0.001 2	0.003 1	0.001 8	0.001 3	0.001 3	0.001 3	0.001 9
CMI	0.002 9	0.003 0	0.002 7	0.002 6		0.002 7	0.003 9	0.003 0	0.002 7	0.002 7	0.002 7	0.003 1
GUM	0.001 9	0.002 0	0.001 4	0.001 2	0.002 7		0.003 2	0.002 0	0.001 5	0.001 5	0.001 5	0.002 1
VMC	0.003 4	0.003 5	0.003 2	0.003 1	0.003 9	0.003 2		0.003 5	0.003 3	0.003 3	0.003 3	0.003 6
SMU	0.002 2	0.002 3	0.002 0	0.001 8	0.003 0	0.002 0	0.003 5		0.001 7	0.001 7	0.001 7	0.002 2
BEV	0.001 8	0.001 9	0.001 6	0.001 3	0.002 7	0.001 5	0.003 3	0.001 7		0.001 1	0.001 2	0.001 8
METAS	0.001 8	0.001 9	0.001 5	0.001 3	0.002 7	0.001 5	0.003 3	0.001 7	0.001 1		0.001 1	0.001 8
INRIM	0.001 8	0.001 9	0.001 6	0.001 3	0.002 7	0.001 5	0.003 3	0.001 7	0.001 2	0.001 1		0.001 8
MIRS	0.002 3	0.002 4	0.002 1	0.001 9	0.003 1	0.002 1	0.003 6	0.002 2	0.001 8	0.001 8	0.001 8	

Figure 1: Differences between participants' results and reference value, and uncertainty (k=2), for 10 kg

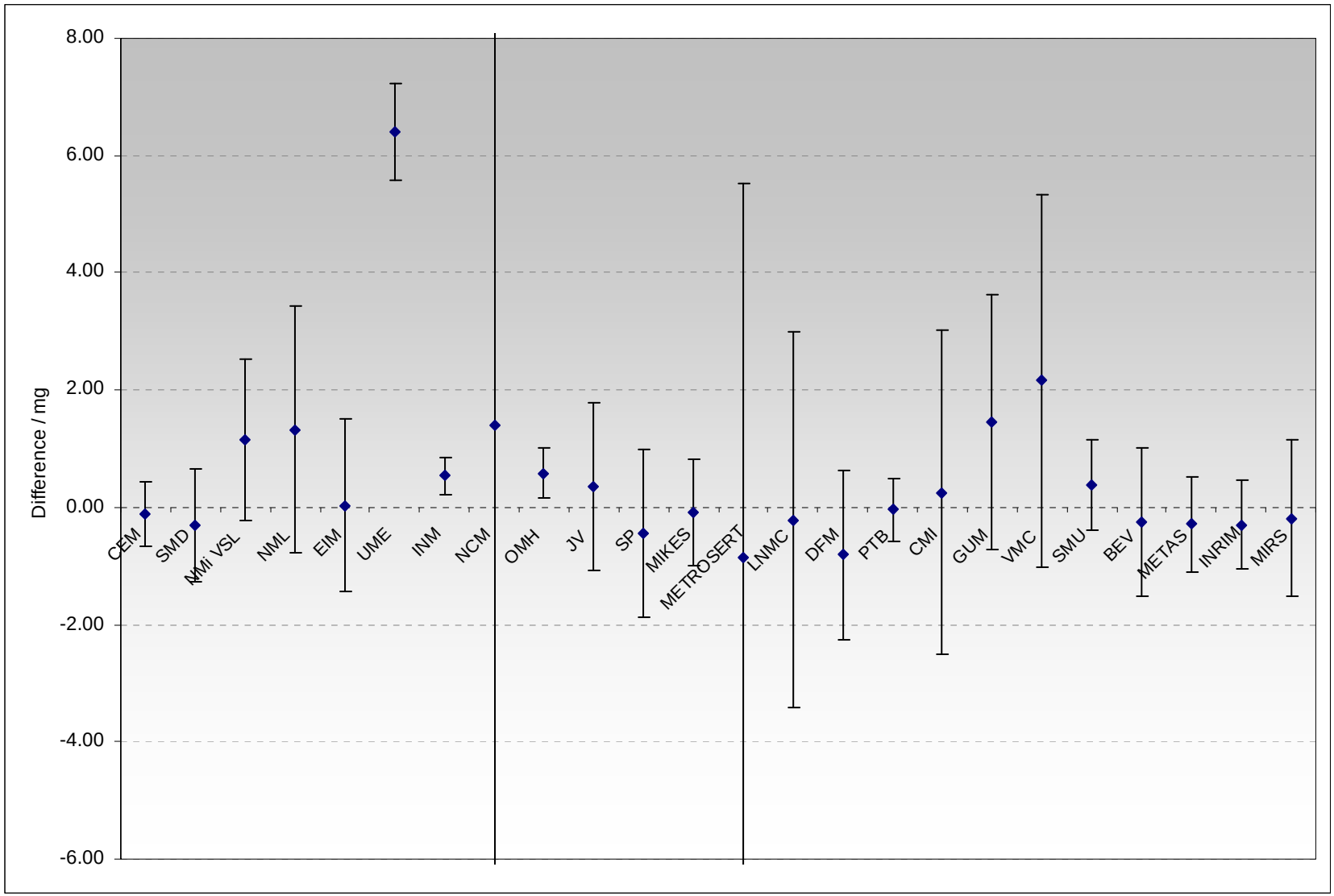


Figure 2: Differences between participants' results and reference value, and uncertainty (k=2), for 500 g

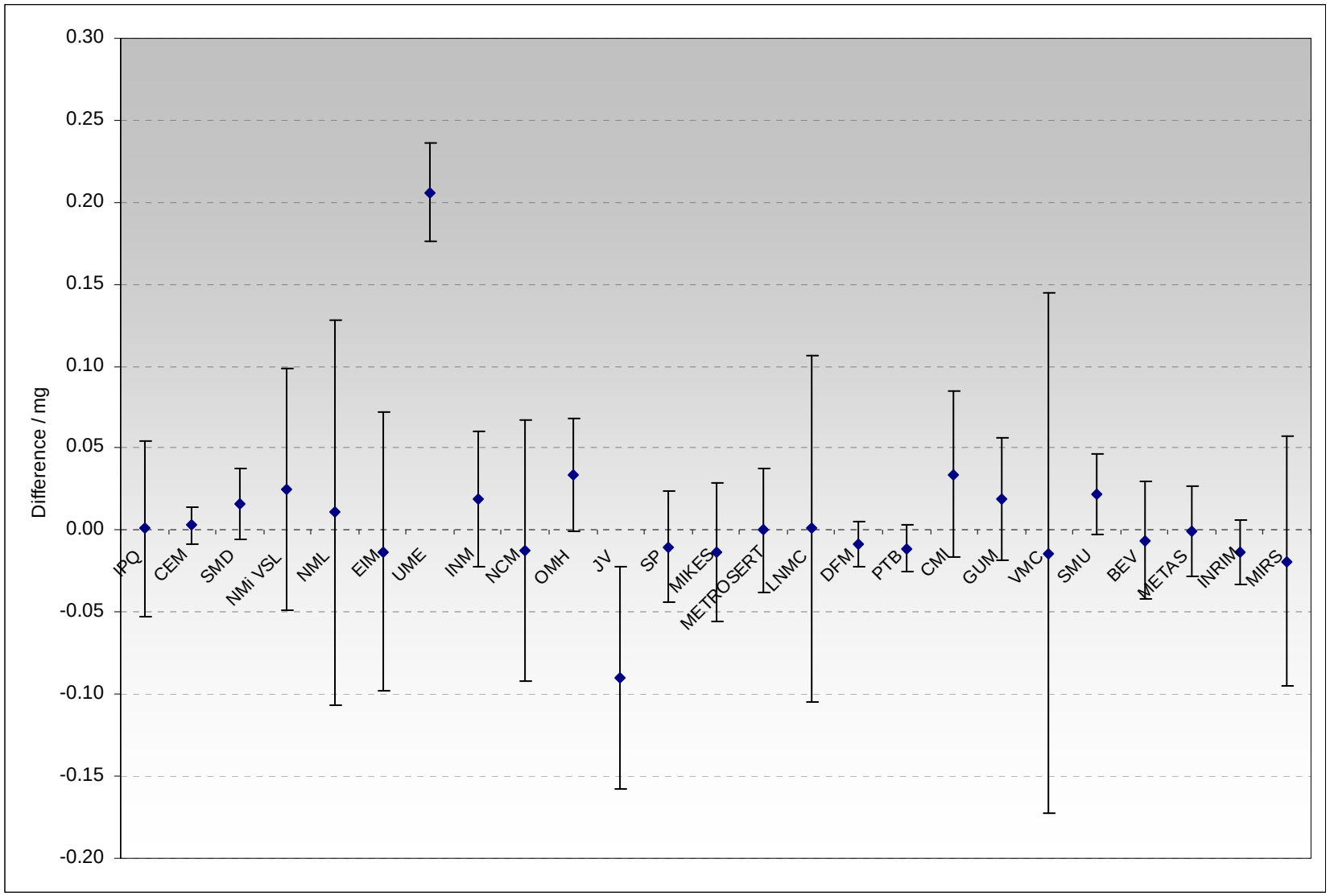


Figure 3: Differences between participants' results and reference value, and uncertainty (k=2), for 20 g

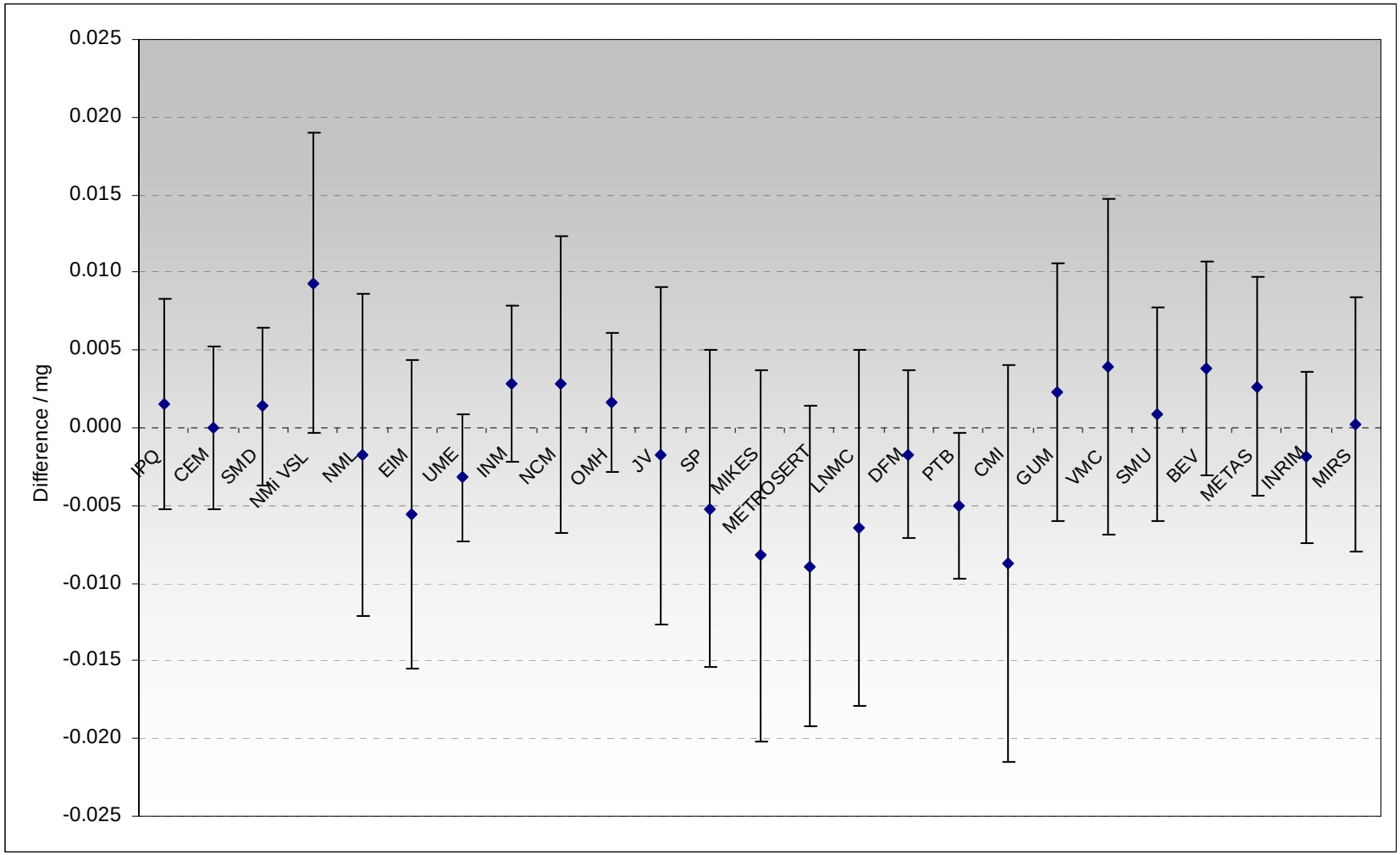


Figure 4: Differences between participants' results and reference value, and uncertainty (k=2), for 2 g

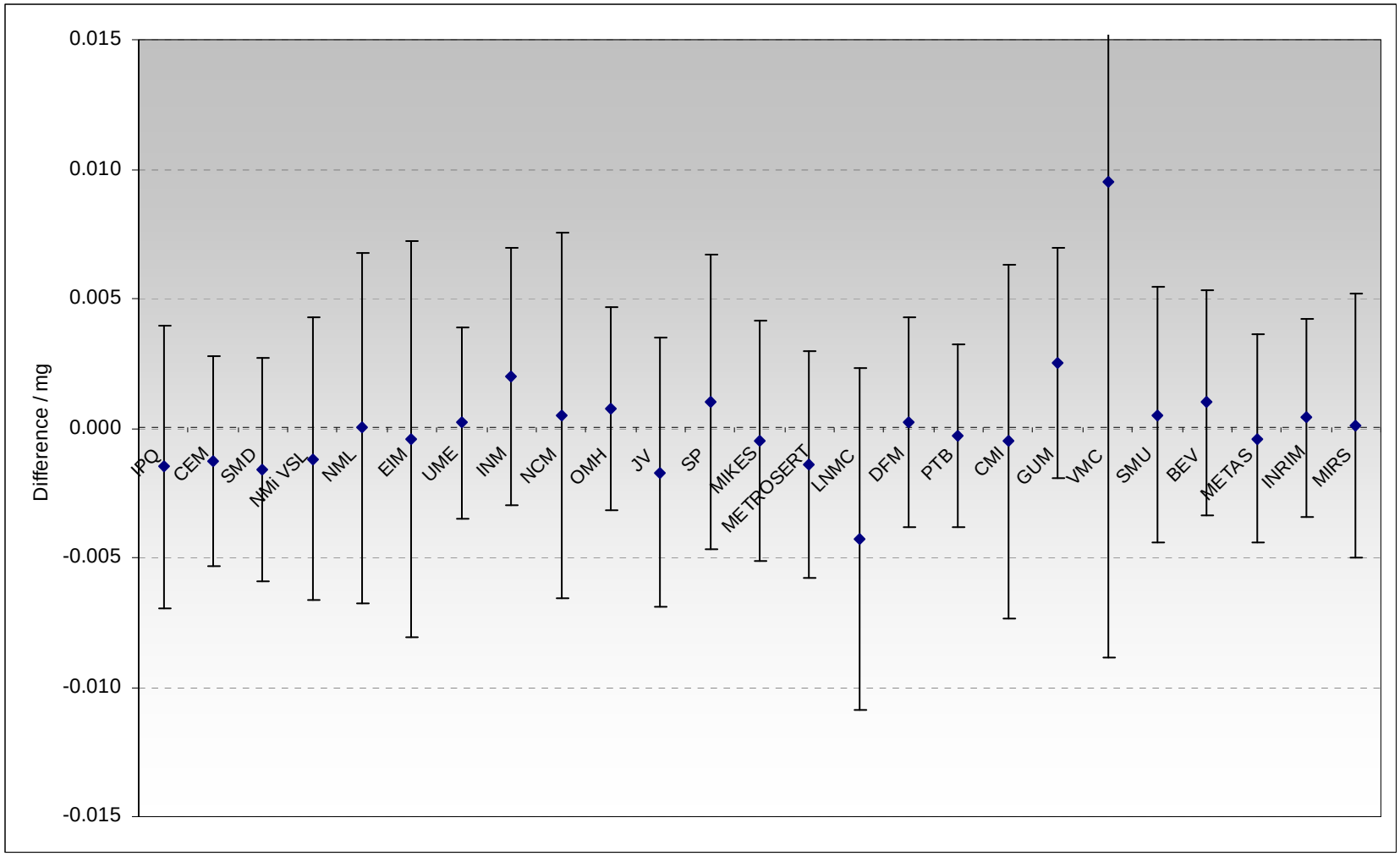
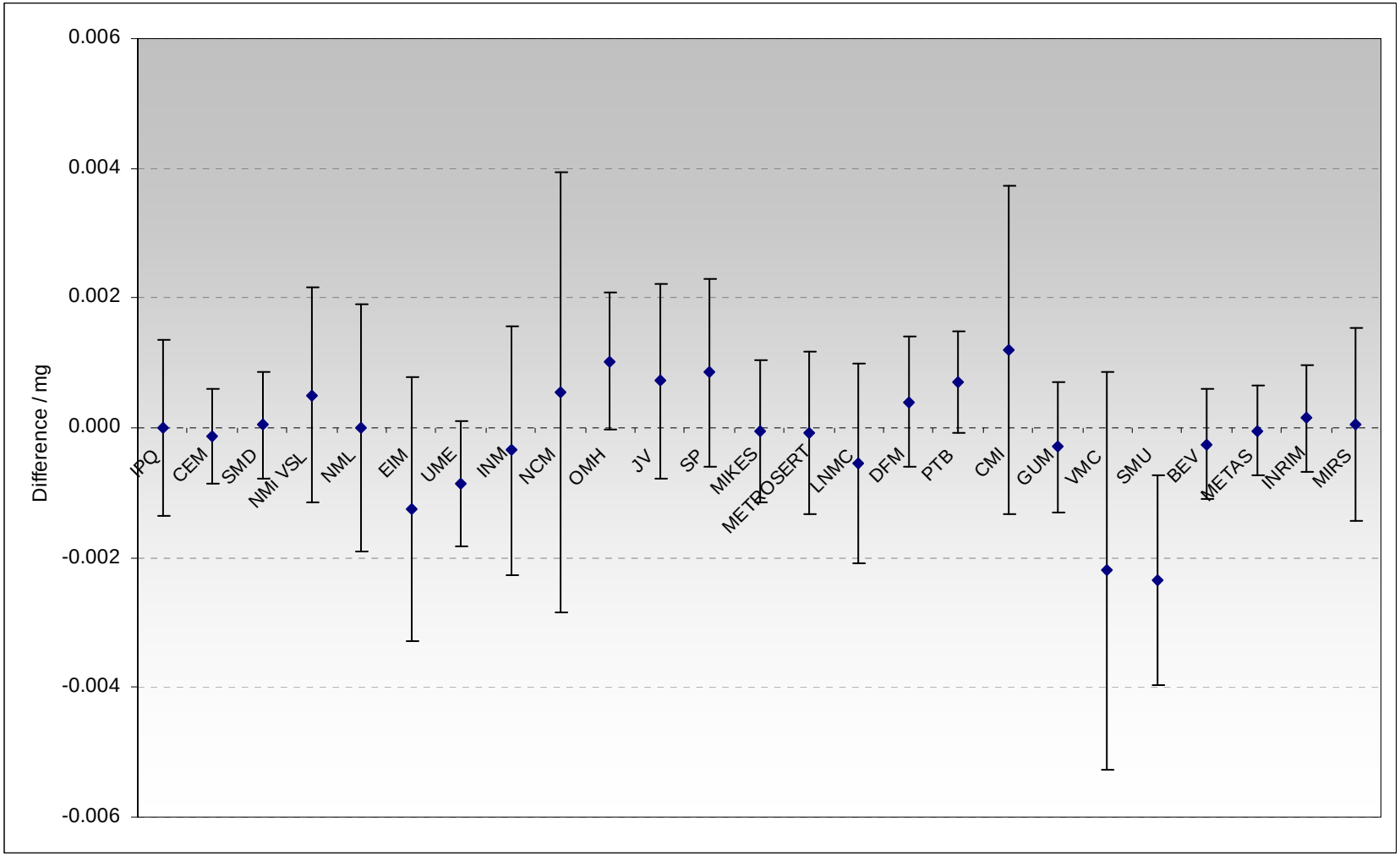


Figure 5: Differences between participants' results and reference value, and uncertainty (k=2), for 100 mg



Appendix A: Linking EUROMET.M.M-K2 to CCM.M-K2

A1. Background

This Appendix describes the method used to link EUROMET.M.M-K2 to CCM.M-K2 which is based upon that described by Sutton [4]. This method of linking was agreed by participants at the EUROMET TC-M meeting held in Teddington in March 2007.

A2. Data

A.2.1 EUROMET.M.M-K2

EUROMET.M.M-K2 is a European Key Comparison of five mass standards (10 kg, 500 g, 20 g, 2 g and 100 mg) in stainless steel comprising 25 laboratories and piloted by SP.

Six sets of transfer standards (referred to as EA, EB, EC, ED, EE and EF) were used, with each comprising five standards. The standards from five of the sets (EB, EC, ED, EE and EF) were circulated among the laboratories, with each set circulated to five laboratories. The pilot laboratory measured all five standards in each set, and the measured data obtained was used as the basis of investigating the stability of the standards.

Information about the measurements made of the transfer standards is provided in Table 2. The information includes (a) the name of the set, (b) the laboratory name, (c) the measured mass difference from nominal value, and (d) the standard uncertainty associated with the measured mass difference.

Information about the measurements made by the pilot laboratory for all six sets of transfer standards during the lifetime of the comparison can be found in Table 3. In this analysis, the pilot laboratory is regarded as an additional laboratory, whose inclusion is necessary to be able to link the five subsets of laboratories which otherwise have no laboratory in common. However, it can be expected that there is correlation associated with the measured values provided by SP regarded as a participating laboratory and SP regarded as the pilot laboratory (see below).

No information is provided about the correlation associated with pairs of measured values. For the purpose of the analysis described here, the following simple “rules” are applied:

- The correlation coefficient associated with a measured value provided by SP regarded as a participating laboratory and a value provided by SP regarded as the pilot laboratory is set as 0.8;
- The correlation coefficient associated with pairs of measured value provided by SP regarded as the pilot laboratory is set as 0.8;
- There is no correlation associated with measured values provided by different laboratories.

The values used for the correlation coefficients are based on the results of discussions between NPL and BIPM metrologists

A.2.2 CCM.M–K2

CCM.M–K2 is a CIPM Key Comparison of five mass standards (10 kg, 500 g, 20 g, 2 g and 100 mg) in stainless steel, comprising 14 laboratories and piloted by PTB. Five of the laboratories (PTB, NMi-VSL, SMU, METAS and INRIM) participated in the EUROMET.M.M-K2 Key Comparison and are used as the basis of linking the two Key Comparisons.

Table 11 of the final CCM.M-K2 report [1] contains the degrees of equivalence for the linking laboratories obtained from the CCM.M–K2 Key Comparison. The degrees of equivalence are expressed as a value d with associated uncertainty reported for a 95 % coverage probability.

For the purposes of linking EUROMET.M.M-K2 and CCM.M–K2 it is necessary to account for the correlation associated with pairs of measured values provided in the two comparisons by the laboratories participating in EUROMET.M.M-K2. In the absence of information about such correlations, the following "simple" rules are applied:

- The correlation coefficient associated with a mass difference measured by a laboratory participating in EUROMET.M.M-K2 and the value component of the degree of equivalence for the laboratory obtained in CCM.M–K2 is set as 0.4;
- The correlation coefficient associated with the value components of the degrees of equivalence for two laboratories participating in CCM.M–K2 is set as 0.4.

The values used for the correlation coefficients are based on the results of discussions between NPL and BIPM metrologists.

A3. Model

Consider one of the masses with nominal mass value m_0.

Let D_i, $i = 1, \ldots, 26$, denote the value component of the degree of equivalence for laboratory i, where $i = 1, \ldots, 25$, identify the laboratories participating in EUROMET.M.M-K2, and $i = 26$ identifies the pilot laboratory of that comparison. Let Δ_k denote the mass difference of the transfer standard k (EB, EC, ED, EE or EF) from the nominal value m_0. Let X_{ik} denote the mass difference of the transfer standard k from the nominal value m_0 measured by laboratory i. Then, a model for X_{ik} in terms of D_i and Δ_k is

$$X_{ik} = D_i + \Delta_k . \qquad (1)$$

Table 2 contains measured values x_{ik} for X_{ik} for $i = 1, \ldots, 25$, and $k = 1, \ldots, 5$. Table 3 contains values x_{ik} for $i = 26$ and $k = 1, \ldots, 5$. Finally, Table 11 in CCM.M-K2 report [1] contains measured values d_i for D_i for $i = 17, 4, 21, 23$ and 24. Assuming that all measurement results are included in the analysis, there are 31 parameters (26 D_i and 5 Δ_k) to be determined and 40 measured values (7 measurements relating to set EB, 7 to set EC, 7 to set ED, 7 to set EE, 7 to set EF and 5 relating to degrees of equivalence for the linking laboratories).

If we denote the vector of parameters by $\mathbf{Y}$ and that of measured quantities by $\mathbf{X}$, then

$$\mathbf{X} = \mathbf{AY},$$

where **A** is a 40 × 31 matrix determined by the relationships (1) and the information provided by CCM.M–K2. Given an estimate **x** of **X** with the associated uncertainty matrix $\mathbf{U}_\mathbf{x}$, an estimate **y** of **Y** with the associated uncertainty matrix $\mathbf{U}_\mathbf{y}$ is found as the solution **z** = **y** to the generalised least-squares problem

$$\min_{\mathbf{z}} \quad (\mathbf{x} - \mathbf{Az})^{\mathrm{T}} \mathbf{U}_\mathbf{x}^{-1} (\mathbf{x} - \mathbf{Az}).$$

The components of **y** contain estimates of the value components of the degree of equivalence for the laboratories (including the pilot laboratory) and information about the transfer standards. The diagonal elements of $\mathbf{U}_\mathbf{y}$ contain the variances (squared standard uncertainties) associated with the estimates **y**.

A4. Model and data consistency

For the model described in section A3 to constitute a valid description of the measurement data, it is necessary to show that the model is consistent with the data taking account of the uncertainties and correlations associated with the data.

For the case of two measured values (z_1 and z_2, say), the values are judged consistent (and therefore realizations of the same quantity) if the magnitude of the difference $r = z_1 - z_2$ is not too large compared with the standard uncertainty $u(r)$ associated with the difference, where $u^2(r) = u^2(z_1) + u^2(z_2) - 2\rho(z_1, z_2)u(z_1)\ u(z_2)$ and $\rho(z_1,\ z_2)$ is the correlation coefficient associated with z_1 and z_2. Regarding the quantities involved as Gaussian, the values are regarded as consistent, at the 95 % level, if

$$| r | < 2u(r).$$

For the case of a model fitted to a general number of measured values, a measure of consistency is the sum of squares of the (uncertainty-) weighted model residuals: the "observed chi-squared value". If the value of this measure is no greater than an appropriate percentile of a chi-squared distribution, here chosen to be the 95 percentile, the model is judged consistent with the data, and inconsistent otherwise. For the model described in section 3, the (uncertainty-) weighted model residuals are

$$\mathbf{r} = \mathbf{L}^{-1}(\mathbf{x} - \mathbf{Ay}), \qquad \mathbf{U}_\mathbf{x} = \mathbf{LL}^{\mathrm{T}},$$

and the chi-squared distribution has degrees of freedom equal to the difference between the number of measured values (e.g., 40) and the number of parameters (e.g., 31).

Tests of consistency are applied to:

1. the five measured values provided for each transfer standard by laboratories participating in EUROMET.M.M-K2;
2. the two measured values provided for each transfer standard by the pilot laboratory of EUROMET.M.M-K2;
3. the five degrees of equivalence provided by the linking laboratories participating in CCM.M–K2.

These tests are used to investigate the consistency of subsets of the measured data. In the case that a subset of the measured data is found to be inconsistent, the results of the test are used as the basis of removing measured values from the subset to ensure consistency. Table 11 records the results of these tests (in terms of which measured data are removed) for each nominal mass value. In the case that the EUROMET.M.M-K2 data for a linking laboratory is removed, the data describing the degree of equivalence for that laboratory obtained from the CCM.M–K2 Key Comparison is also removed.

A test of consistency is also applied to the model described in section 3 and the complete set of measured data (with data removed as described in Table 11). This test is used to investigate whether the model constitutes a valid description of the "union" of the different subsets of the measured data. For the results indicated in section 5, this test of consistency is passed.

For a laboratory participating in EUROMET.M.M-K2 that has been removed from the analysis (e.g., UME for the 10 kg mass standard), the value component of the degree of equivalence for that laboratory is evaluated from

$$d = x - x_{\mathrm{ref}},$$

with associated standard uncertainty $u(d)$ given by

$$u^2(d) = u^2(x) + u^2(x_{\mathrm{ref}}),$$

where x is the measured value provided by the laboratory and x_{ref} is an estimate of the mass difference Δ for the transfer standard measured by the laboratory.

Nominal mass m_0	**Measured data removed from analysis**
10 kg	IPQ (no value supplied) and UME measured data from EUROMET.M.M-K2
500 g	UME and JV measured data from EUROMET.M.M-K2 Pilot measured data for EC and EF (one each) from EUROMET.M.M-K2 NMi-VSL degree of equivalence from CCM.M–K2
20 g	UME measured data from EUROMET.M.M-K2 Pilot measured data for EB and EF (one each) from EUROMET.M.M-K2 SMU degree of equivalence from CCM.M–K2
2 g	–
100 mg	OMH, PTB and SMU measured data from EUROMET.M.M-K2 Pilot measured data for EC (one value) from EUROMET.M.M-K2 PTB and SMU degrees of equivalence from CCM.M–K2

Table 11 For each nominal mass value, the measured data removed from the analysis to ensure data consistency.

A5. Results

The results from the linkage are given in Table 12. Using these data it is possible to calculate the degree of equivalence between any of the laboratories participating in EUROMET.M.M-K2 and those participating in CCM.M–K2.

Table 12: Differences between participants' results and CCM.M-K2 reference value, Δm, and associated k=2 uncertainties, $U_{\Delta m}$

		IPQ	CEM	SMD	NMi VSL	NML	EIM	UME	INM	NCM	OMH	JV	SP	MIKES
10 kg	Δm/mg		-0.21	-0.40	0.52	1.22	0.06	6.43	0.56	1.43	0.60	0.40	-0.29	-0.04
	$U_{\Delta m}$/mg		1.07	1.24	1.58	2.33	1.91	1.12	0.87	26.01	0.92	1.82	1.56	1.36
500 g	Δm/mg	0.004	0.006	0.019	0.028	0.014	0.017	0.236	0.049	0.018	0.064	-0.088	0.005	-0.011
	$U_{\Delta m}$/mg	0.069	0.034	0.039	0.082	0.128	0.087	0.030	0.047	0.086	0.036	0.070	0.036	0.048
20 g	Δm/mg	0.001	-0.001	0.001	0.005	-0.002	-0.001	0.001	0.007	0.007	0.006	0.002	0.000	-0.004
	$U_{\Delta m}$/mg	0.008	0.007	0.007	0.009	0.012	0.011	0.006	0.007	0.011	0.007	0.008	0.008	0.010
2 g	Δm/mg	-0.002 3	-0.002 1	-0.002 4	-0.001 9	-0.000 8	-0.001 0	-0.000 4	0.001 4	-0.000 1	0.000 2	-0.001 3	0.001 4	-0.000 1
	$U_{\Delta m}$/mg	0.004 2	0.002 1	0.002 3	0.004 3	0.006 3	0.007 2	0.002 0	0.003 5	0.006 5	0.002 0	0.003 7	0.003 0	0.003 3
100 mg	Δm/mg	0.000 2	0.000 1	0.000 3	0.001 0	0.000 2	-0.000 5	-0.000 1	0.000 4	0.001 3	0.001 8	0.000 9	0.001 3	0.000 1
	$U_{\Delta m}$/mg	0.001 7	0.001 1	0.001 2	0.001 6	0.002 2	0.002 1	0.001 2	0.002 1	0.003 6	0.001 2	0.001 7	0.001 4	0.001 4

		METROS	LNMC	DFM	PTB	CMI	GUM	VMC	SMU	BEV	METAS	INRIM	MIRS
10 kg	Δm/mg	-0.80	-0.18	-0.79	-0.03	0.28	1.48	2.18	0.74	-0.05	0.04	-0.27	0.01
	$U_{\Delta m}$/mg	6.45	3.47	1.58	0.30	3.06	2.28	3.26	1.06	1.50	0.51	0.47	1.60
500 g	Δm/mg	0.002	0.003	0.002	0.001	0.045	0.030	-0.003	0.043	0.017	0.020	0.013	0.004
	$U_{\Delta m}$/mg	0.050	0.114	0.020	0.013	0.052	0.042	0.161	0.025	0.043	0.028	0.016	0.078
20 g	Δm/mg	-0.005	-0.002	0.001	-0.002	-0.006	0.005	0.007	0.002	0.005	0.005	0.000	0.001
	$U_{\Delta m}$/mg	0.007	0.010	0.006	0.005	0.013	0.009	0.011	0.008	0.007	0.007	0.006	0.010
2 g	Δm/mg	-0.001 0	-0.003 9	0.000 2	-0.000 3	-0.000 5	0.002 5	0.009 5	0.000 5	0.001 0	0.000 6	0.000 4	0.000 1
	$U_{\Delta m}$/mg	0.002 7	0.005 5	0.002 4	0.001 5	0.006 2	0.002 4	0.018 1	0.003 4	0.002 6	0.002 1	0.002 2	0.004 3
100 mg	Δm/mg	0.000 1	-0.000 4	0.000 7	0.001 0	0.001 5	0.000 0	-0.001 9	-0.002 2	-0.000 1	0.000 1	0.000 3	0.000 2
	$U_{\Delta m}$/mg	0.001 6	0.001 7	0.001 3	0.001 1	0.002 6	0.001 3	0.003 2	0.001 6	0.001 0	0.000 9	0.001 0	0.001 8