Certification Report

Certified Reference Material

BAM-M396

CuZn33Pb1AlSiAs

March 2019

Coordinator: Dr. Sebastian Recknagel
Bundesanstalt für Materialforschung und -prüfung (BAM)
Division 1.6 „Inorganic Reference Materials“
Richard-Willstätter-Str. 11
12489 Berlin
Phone: ++49/30/8104 1111
Fax.: ++49/30/8104 1117
E-mail: sebastian.recknagel@bam.de

Summary

This report describes preparation, analysis and certification of copper based reference material BAM-M396, CuZn33Pb1AlSiAs (AQCUARIN).
The certified reference material (CRM) is available in the form of discs (40 mm diameter and 30 mm height). It is intended for establishing and checking the calibration of spark optical emission and X-ray fluorescence spectrometers for the analysis of samples of similar materials. It is also suitable for wet chemical analysis.

The following mass fractions and uncertainties have been certified:

Element	Mass fraction [1] in %	Uncertainty [2] in %
Cu	65.49	0.12
Pb	0.592	0.014
Fe	0.0235	0.0012
Sn	0.0367	0.0011
Al	0.223	0.010
As	0.0590	0.0016
Si	0.187	0.008
	in mg/kg	**in mg/kg**
Bi	3.2	0.03
Cd	2.2	0.2
Co	1.2	0.1
Cr	7.9	0.7
Mn	44.5	1.9
Ni	143	17
P	8.9	1.0
Sb	6.1	0.7

[1] Unweighted mean value of the means of accepted sets of data (consisting of at least 5 but usually 6 single results), each set being obtained by a different laboratory and/or a different method of measurement.

[2] Estimated expanded uncertainty U with a coverage factor of $k = 2$, corresponding to a level of confidence of approx. 95 %, as defined in the Guide to the Expression of Uncertainty in Measurement, (GUM, ISO/IEC Guide 98-3:2008).

The certified values are based on the results of eight laboratories which participated in the certification inter-laboratory comparison.

The mass fraction of Se is given as value for information (< 10 mg/kg).

Content

List of abbreviations
(if not explained elsewhere)

CRM	certified reference material
ETAAS	electrothermal atomic absorption spectrometry
FAAS	flame atomic absorption spectrometry
ICP-OES	inductively coupled plasma optical emission spectrometry
ICP-MS	inductively coupled plasma mass spectrometry
SOES	spark optical emission spectrometry
XRF	X-ray fluorescence spectrometry
M	mean value
n	number of accepted data sets
s	standard deviation of an individual data set
s_M	standard deviation of laboratory means
s_{rel}	relative standard deviation
$\bar{s}_i$	square root of mean of variances of data sets under repeatability conditions
M_i	single result
I	ICP-OES (Tables 2 – 17)
I(R)	ICP-OES, revised value (Tables 2 – 17)
IMS	ICP-MS (Tables 2 – 17)
A	FAAS (Tables 2 – 17)
A(R)	FAAS, revised value (Tables 2 – 17)
EA	ETAAS (Tables 2 – 17)
EA(R)	ETAAS, revised value (Tables 2 – 17)
EA-Cu	ETAAS after electrolytical separation of Cu (Tables 2 – 17)
EG	electrogravimetry (Tables 2 – 17)
P	spectrophotometry (Tables 2 – 17)
G	gravimetry (Tables 2 – 17)

1. Introduction

In the metal-producing and metal-working industry mainly spark optical emission spectrometry (SOES) and X-ray fluorescence spectrometry (XRF) are used for reception inspection of raw materials, e.g. scrap, for quality control of end products and production control. These time-saving analytical techniques require suitable reference materials for calibration and recalibration.

AQCUARIN is foreseen as a material which could replace lead containing brasses in the automotive industry as well as in drinking water applications. The idea to produce an AQCUARIN reference material was the outcome of discussions within CEN TC 133 Copper and Copper Alloys and within the German Gesellschaft der Metallurgen und Bergleute e.V. (GDMB), especially of the working group „Copper" of the Committee of Chemists within GDMB. The needs are defined by this working group, since the members are potential users of the prepared CRMs. Participating laboratories were recruited from this group. Since all the laboratories participating in this certification project are highly experienced with copper and brass analysis and had participated in earlier inter-laboratory comparisons, there was no preceding round robin for qualification.

Certification of reference material BAM-M396 was carried out on the basis of ISO 17034 [1] and the relevant ISO-Guides [2, 3].

2. Companies/laboratories involved

Manufacturing of the material

– Diehl Metall Stiftung & Co KG, Röthenbach, Germany

Test for homogeneity

– Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany

Participants in the certification inter-laboratory comparison

– Aurubis AG, Hamburg, Germany
– Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany
– Diehl Metall Stiftung & Co KG, Röthenbach, Germany
– Institute of Non-Ferrous Metals, Gliwice, Poland
– KM Europa Metal AG, Osnabrück, Germany
– KME Brass Germany GmbH, Berlin, Germany
– VDM-Metals GmbH, Werdohl, Germany
– Wieland-Werke AG, Vöhringen, Germany

Additional participants in the spark emission inter-laboratory comparison

– Deutsches Kupferinstitut, Düsseldorf, Germany
– Institut für Umformtechnik, Lüdenscheid, Germany
– revierlabor, Essen, Germany
– W.S. Werkstoff Service GmbH, Essen, Germany

Statistical evaluation of the data

– Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany

3. Candidate material

CuZn33Pb1AlSiAs was taken from the normal production process within Diehl Metall Stiftung & Co KG, Röthenbach. From the raw material rods were cast by Diehl Metall Stiftung. After solidification the material was pressed to five rods with a diameter of ca. 40 mm and ca. 4 m length each. From these rods four samples per rod (in total 20) were cut for homogeneity testing and chemical analysis, see Figure 1.

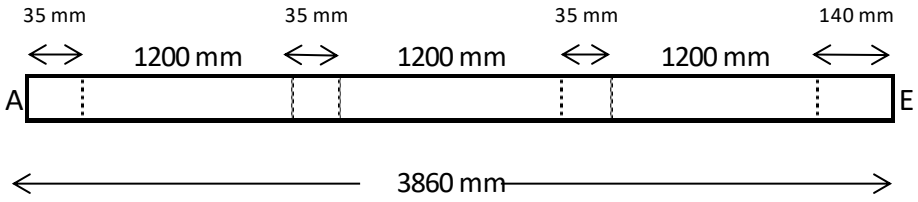


Figure 1: Cutting plan of CuZn33Pb1AlSiAs reference materials

About 530 discs with a diameter of ca. 40 mm and 30 mm were received from the total batch.

4. Homogeneity testing

Possible reasons for an inhomogeneous distribution of elements in the raw material may be a change of the composition of the melt during the casting procedure because some elements may volatise or because of possible segregation during the solidification of the material. Since the raw material was produced by casting of a rod, concentration gradients can occur over the length of the rod (axial) as well as over the area of the rod (radial, see Figure 2):

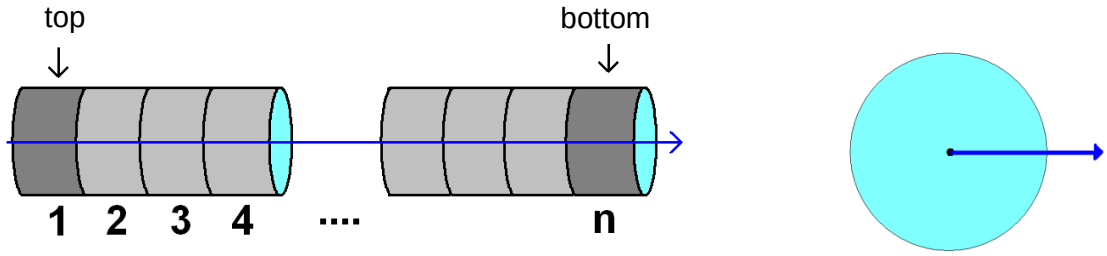


Fig. 2: Axial and radial composition gradient

Therefore, it is necessary to investigate the raw material for both axial and radial inhomogeneities. Axial homogeneity testing of the candidate material was performed on the 20 discs using spark emission spectrometry. All tests were carried out with a SpectroLab spark emission spectrometer. Each disc was analysed six times. The signals for Cr on the used Instruments were too low for inhomogeneity calculation. Therefore, the data obtained for Sb was used to calculate the uncertainty contribution of possible inhomogeneity of Cr. The mass fractions of Sb and Cr are very similar and from other certifications in the past it is well known, that these traces behave very similar.
Homogeneity testing of copper was done using XRF. An estimation of inhomogeneity was obtained by subtracting the variance of the copper content in the samples tested for homogeneity from the variance obtained by measuring the same sample 10 times (s(instrument). This was done only over the length of the rods.

The estimate of analyte-specific inhomogeneity contribution u_{bb} to be included into the total uncertainty budget was calculated according to ISO Guide 35 [3] using Eq. (1) and Eq. (2):

$$s_{bb} = \sqrt{\frac{MS_{among} - MS_{within}}{n}} \qquad (1)$$

$$u^*_{bb} = \sqrt{\frac{MS_{within}}{n}} \sqrt[4]{\frac{2}{N(n-1)}} \qquad (2)$$

where:

MS_{among}	mean of squared deviations between discs (from 1-way ANOVA, see Annex 1)
MS_{within}	mean of squared deviations within one disc (from 1-way ANOVA)
n	number of replicate measurements per disc
N	number of discs selected for homogeneity study

s_{bb} signifies the between-discs standard deviation, whereas u^*_{bb} denotes the maximum heterogeneity that can potentially be hidden by an insufficient repeatability of the applied measurement method (which has to be considered as the minimum uncertainty contribution). In any case the larger of the two values was used as u_{bb}(1). Eq. (1) does not apply if MS_{within} is larger than MS_{among}.

In addition to the tests performed over the length of the rods, three discs were tested for homogeneity over the area (possible segregation from the outer part to the centre). To perform this test, SOES analysis was carried out in circles (outer circle: 8 sparks, inner circle: 4 sparks; centre: 1 spark). For the elements Pb, Sn and As the mass fraction of the element in the centre of the disc differed from those outer parts. Therefore, sparking in the centre has to be avoided.

The analyte-specific within-disc uncertainty component u_{bb}(2) was calculated in the same way as for the total batch. To calculate the necessary data an unbalanced ANOVA was carried out taking into account that the number of single measurements is different for the centre, the inner and the outer circle. For technical reasons, at r_0 (centre) only one measurement is possible. An ANOVA requires a minimum of two measurements per factor value. Thus, the value for r_0 should be replaced by a dummy. This dummy is defined as follows:

The two values replacing the one measured have a mean equal to the value measured, and a standard deviation equal to the average within-variation. This resembles the situation were one could take two independent measurements at the same place, with values deviating by the average standard deviation (non-destructive testing method). A first guess for the average standard deviation may be calculated from the data for r_in (inner circle) and r_out (outer circle). As results from these calculations an inhomogeneity factor for the radius and one for the height of the disc is obtained. From these values a combined inhomogeneity factor is calculated. This factor is compared with the within standard deviation calculated from the ANOVA data. The higher factor is used for uncertainty calculation. Annex 2 shows the results of the calculations.

5. Characterisation study

5.1 Analytical methods

Eight laboratories participated in the certification inter-laboratory comparison. All laboratories were highly experienced in the analysis of copper and copper alloys and participated successfully in former certification inter-laboratory comparisons. For some elements part of the laboratories used more than one analytical method reporting more than one data set.

The laboratories were asked to analyse six subsamples. They were free to choose any suitable analytical method for their determinations. Table 1 shows the analytical methods used by the participating laboratories.

Table 1: Analytical procedures used by the participating laboratories

Lab-No.	Element.	Sample mass	Sample pretreatment	Analytical method
1	Al, As, Fe, Mn, Ni, P, Si, Sn	1 g	Dissolution with HCl, HNO_3, H_3BO_3, HF	ICP-OES (DIN EN 15605), calibration with commercial solutions (Merck), matrix matching with Cu
	Cu	1 g	Dissolution with HNO_3	Electrogravimetry
	Cr	0.1 g	Dissolution with HNO_3, HF	ETAAS, calibration with commercial solution (Merck), matrix matching with Cu
	Bi, Cd, Se	0.5 g	Dissolution with HNO_3, HF	ETAAS, calibration with commercial solution (Merck), matrix matching with Cu
	Co	1 g	Dissolution with HNO_3, HF	ETAAS, calibration with commercial solution (Merck), matrix matching with Cu
	Sb	0.2 g	Dissolution with HNO_3, HF	ETAAS, calibration with commercial solution (Merck), matrix matching with Cu
2	Fe, Pb, Ni	1 g	Dissolution with HNO_3, HCl	FAAS, calibration with standard solutions prepared of pure metals, matrix matching with Cu and Zn
	Al, Mn	1 g	Dissolution with HCl/H_2O_2	FAAS, calibration with commercial solution (Merck), matrix matching with Cu and Zn
	Si	2.5 g	Dissolution with HCl/HNO_3	Gravimetry, dehydration with hydrochloric acid
	Cu	1.5 g	Dissolution with HNO_3, H_3BO_3, HF	Electrogravimetry (DIN EN 16117-1), determination of residue with ICP-OES
	As, Bi, Cd, Co, Cr, Sn	1 g	Dissolution with HNO_3, HF	ETAAS, calibration with calibration with commercial solution (Merck)
	Fe	5 g	Dissolution with HCl	Spectrophotometry, calibration with standard solutions prepared of pure metal
	Sn	1.5 g	Dissolution with HNO_3, H_3BO_3, HF	ETAAS after electrolytic separation of Cu, calibration with calibration with commercial solution (Merck)
	P	2 g	Dissolution with HCl/HNO_3	Spectrophotometry, calibration with commercial solution (Merck)
3	Cu	2 g	Dissolution with HNO_3, + H_2SO_4, NaCl	Electrogravimetry
	Sn, Mn, P, Ni, Sb, Cd, Co, Cr	1 g	Dissolution with HF/HNO_3	ICP-OES, calibration with commercial solutions (Spex), matrix matching with Cu
	Fe, As, Pb, Al	0.5 g	Dissolution with HF/HNO_3	ICP-OES, calibration with commercial solutions (Spex), matrix matching with Cu
	Se	0.2 g	Dissolution with HNO_3	ICP-MS, calibration with commercial solutions (Spex), matrix matching with Cu
4	Cu	1 g	Dissolution with HNO_3/HF	Electrogravimetry
	Pb, Fe, Mn, Al, Si, As	1 g	Dissolution with HNO_3/HF	ICP-OES with matrix matched standards (Cu, Zn), commercial mono-element solutions
	Sn, Ni, Sb, Se, Bi, Cd, Co, Cr	1 g	Dissolution with HNO_3/HF	ICP-MS with matrix matched standards (Cu, Zn), commercial mono-element solutions

Table 1 (cont.): Analytical procedures used by the participating laboratories

Lab-No.	Element.	Sample mass	Sample pretreatment	Analytical method
8	Cu	1 g	Dissolution with HNO_3	Electrogravimetry
	Si	3 g	Dissolution with HNO_3	Gravimetry, dehydration with perchloric acid
	P, Sn	1 g	Dissolution with $HCl/HNO_3/HF$	ICP-OES with matrix matched standards (Cu, Zn), commercial mono-element solutions (traceable via NIST-SRM)
	Fe, Ni	0.5 g	Dissolution with HNO_3/HF	ICP-OES with matrix matched standards (Cu, Zn), commercial mono-element solutions (traceable via NIST-SRM)
	Pb, Sn, Mn, Al, As, Cd	0.2 g	Dissolution with HNO_3/HF	ICP-OES with matrix matched standards (Cu, Zn), commercial mono-element solutions (traceable via NIST-SRM)
	Sb, Se, Bi	0.2 g	Dissolution with HNO_3/HF	ETAAS with matrix matched standards (Cu, Zn), commercial mono-element solutions (traceable via NIST-SRM)
	Co, Cr	1 g	Dissolution with HNO_3/HF	ICP-OES with matrix matched standards (Cu, Zn), commercial mono-element solutions (traceable via NIST-SRM)
9	Cu	1 g	Dissolution with HNO_3	Electrogravimetry
	Pb, Sn, Mn, Ni, Al, As, Si, Se	1 g	Dissolution with HCl/H_2O_2	ICP-OES with matrix matched standards (Cu, Zn), commercial mono-element solutions
10	Cu	1 g	Dissolution with HNO_3	Electrogravimetry (DIN EN 16117-1)
	Al, As, Bi, Cd, Co, Cr, Fe, Mn, Ni, P, Pb, Sb, Si, Se, Sn	1 g	Dissolution with HNO_3/HF	ICP-OES (DIN EN 15605), with matrix matched standards (Cu, Zn), commercial certified mono-element solutions
11	Cu	1 g	Dissolution with HNO_3	Electrogravimetry
	Si	0.2 g	Dissolution with HNO_3/HF	ICP-OES, calibration with commercial mono-element solution, matrix matching (Cu)
	Pb, Fe, Sn, Mn, Ni, Al, As, P, Sb, Se, Bi, Cd, Co, Cr	1 g	Dissolution with HCl/H_2O_2	ICP-OES, calibration with commercial mono-element solution, matrix matching (Cu)

For all analytical methods where a calibration was necessary it was performed using liquid standard solutions. All participating laboratories were asked to use only standard solutions prepared from pure metals or stoichiometric compounds or well checked commercial calibration solutions.

5.2 Analytical results and statistical evaluation

The analytical results of the inter-laboratory certification comparison are listed in Tables 2 to 17. These tables show the single results (M_i) of each laboratory, the respective laboratories' mean values (M), absolute and relative intra-laboratory standard deviation (s and s_{rel}, respectively), the standard deviation of laboratory means (s_M), and in addition the square root of mean of variances of data sets under repeatability conditions ($\bar{s}_i$). n is the number of accepted data sets. The continuous line marks the certified value (mean of the laboratories' means), the broken lines mark the standard deviation, calculated from the laboratories' means.
In the related figures for each laboratory its mean value and single standard deviation is given.

Table 2: Results for Cu

Lab./Meth.	11/EG	3/EG	9/EG	10/EG	8/EG	4/EG	1/EG	2/EG		
M_i [%]	65.44	65.43	65.48	65.46	65.49	65.49	65.54	65.68		*n*
	65.42	65.44	65.46	65.48	65.50	65.47	65.54	65.71		8
	65.42	65.44	65.44	65.48	65.47	65.49	65.53	65.63		
	65.44	65.45	65.47	65.47	65.48	65.50	65.57	65.39		
	65.43	65.45	65.46	65.46	65.48	65.51	65.56	65.53		
	65.43	65.45	65.44	65.46	65.48	65.51	65.59	65.56		
***M* [%]**	**65.43**	**65.44**	**65.46**	**65.47**	**65.48**	**65.49**	**65.56**	**65.58**		**65.49**
s[%]	0.0089	0.0069	0.0160	0.0098	0.0105	0.0170	0.0226	0.1169		0.0540
									s_M [%]	0.0434
s_{rel}	0.00014	0.00011	0.00024	0.00015	0.00016	0.00026	0.00034	0.00178	$\bar{s}_i$ [%]	0.00082

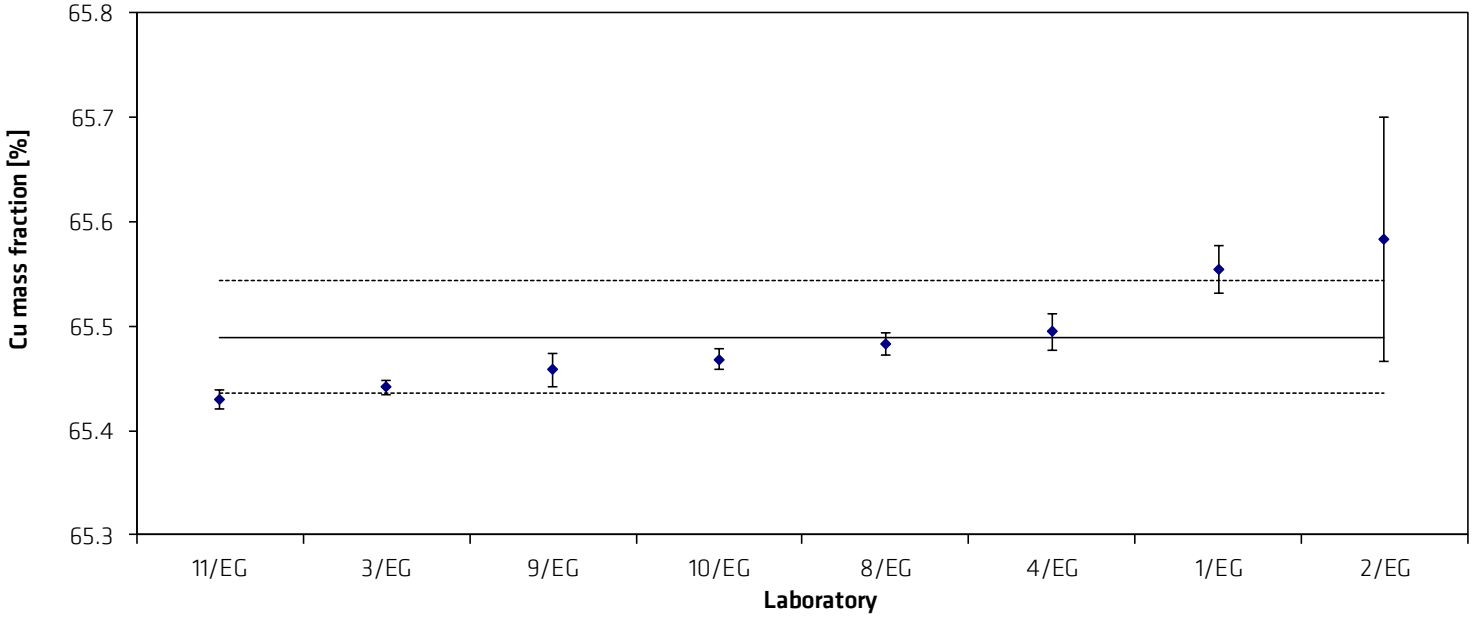


Table 3: Results for Pb

Lab./Meth.	2/A	3/I	10/I	8/I	11/I	9/I	4/I (R)	1/EG		
M_i [%]	0.569	0.570	0.581	0.590	0.598	0.590	0.605	0.610		*n*
	0.564	0.568	0.581	0.597	0.599	0.598	0.602	0.610		8
	0.573	0.566	0.582	0.592	0.600	0.606	0.603	0.600		
	0.565	0.568	0.586	0.595	0.599	0.591	0.603	0.620		
	0.564	0.566	0.586	0.597	0.596	0.607	0.604	0.630		
	0.565	0.569	0.587	0.598	0.601	0.601	0.603	0.640		
M [%]	**0.567**	**0.568**	**0.584**	**0.595**	**0.599**	**0.599**	**0.603**	**0.618**		**0.592**
s[%]	0.004	0.002	0.003	0.003	0.002	0.007	0.001	0.015		0.018
									s_M [%]	0.0062
s_{rel}	0.007	0.003	0.005	0.005	0.003	0.012	0.002	0.024	$\bar{s}_i$ [%]	0.030

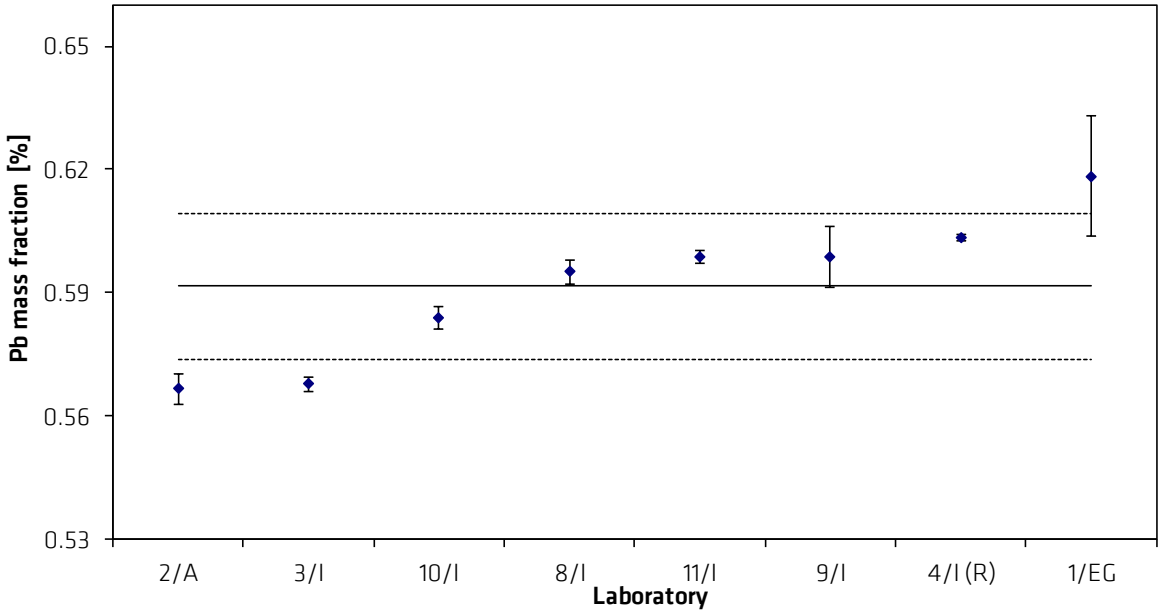


Table 4: Results for Fe

Lab./Meth.	2/A	10/I	8/I	3/I	11/I	1/I	2/P	4/I		
M_i [%]	0.0208	0.0217	0.0233	0.0236	0.0239	0.0250	0.0257	0.0255		*n*
	0.0207	0.0218	0.0232	0.0234	0.0237	0.0228	0.0248	0.0253		8
	0.0208	0.0214	0.0232	0.0240	0.0232	0.0254	0.0247	0.0253		
	0.0211	0.0214	0.0232	0.0234	0.0233	0.0245	0.0245	0.0253		
	0.0207	0.0217	0.0232	0.0233	0.0239	0.0249	0.0259	0.0256		
	0.0204	0.0218	0.0231	0.0237	0.0237	0.0247	0.0245	0.0251		
***M* [%]**	**0.0208**	**0.0216**	**0.0232**	**0.0236**	**0.0236**	**0.0245**	**0.0250**	**0.0254**		**0.0235**
s[%]	0.0002	0.0002	0.0001	0.0002	0.0003	0.0009	0.0006	0.0002		0.0016
									s_M [%]	0.0004
s_{rel}	0.0113	0.0086	0.0027	0.0098	0.0122	0.0366	0.0248	0.0069	$\bar{s}_i$ [%]	0.068

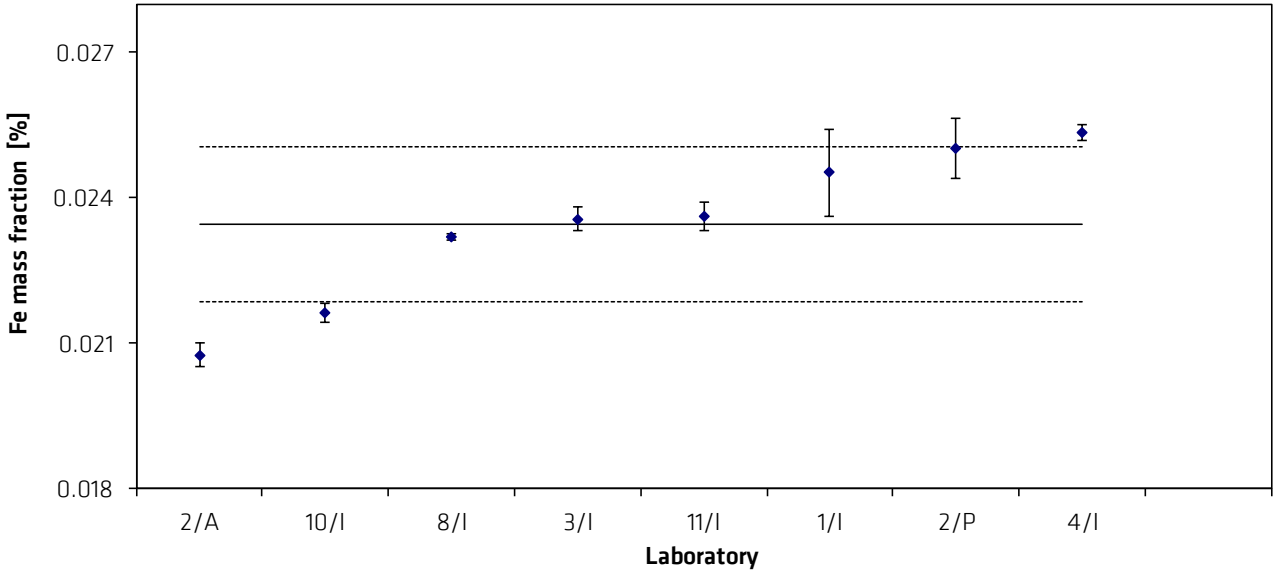


Table 5: Results for Sn

Lab./Meth.	4/IMS	2/EA-Cu	2/EA	8/I(R)	3/I	10/I	11/I	9/I	1/I		
M_i [%]	0.0342	0.0368	0.0344	0.0371	0.0367	0.0371	0.0373	0.0378	0.0412		*n*
	0.0351	0.0353	0.0349	0.0354	0.0367	0.0371	0.0380	0.0374	0.0372		9
	0.0350	0.0341	0.0355	0.0358	0.0368	0.0370	0.0375	0.0391	0.0386		
	0.0355	0.0342	0.0370	0.0368	0.0369	0.0369	0.0374	0.0385	0.0385		
	0.0336	0.0357	0.0354	0.0370	0.0372	0.0373	0.0371	0.0386	0.0384		
	0.0346	0.0359	0.0361	0.0365	0.0368	0.0373	0.0376	0.0394	0.0380		
M [%]	**0.0347**	**0.0353**	**0.0356**	**0.0364**	**0.0368**	**0.0371**	**0.0375**	**0.0385**	**0.0387**		**0.0367**
s[%]	0.0007	0.0010	0.0009	0.0007	0.0002	0.0002	0.0003	0.0008	0.0014		0.0014
										s_M [%]	0.0008
s_{rel}	0.0198	0.0294	0.0257	0.0188	0.0049	0.0043	0.0083	0.0197	0.0352	$\bar{s}_i$ [%]	0.037

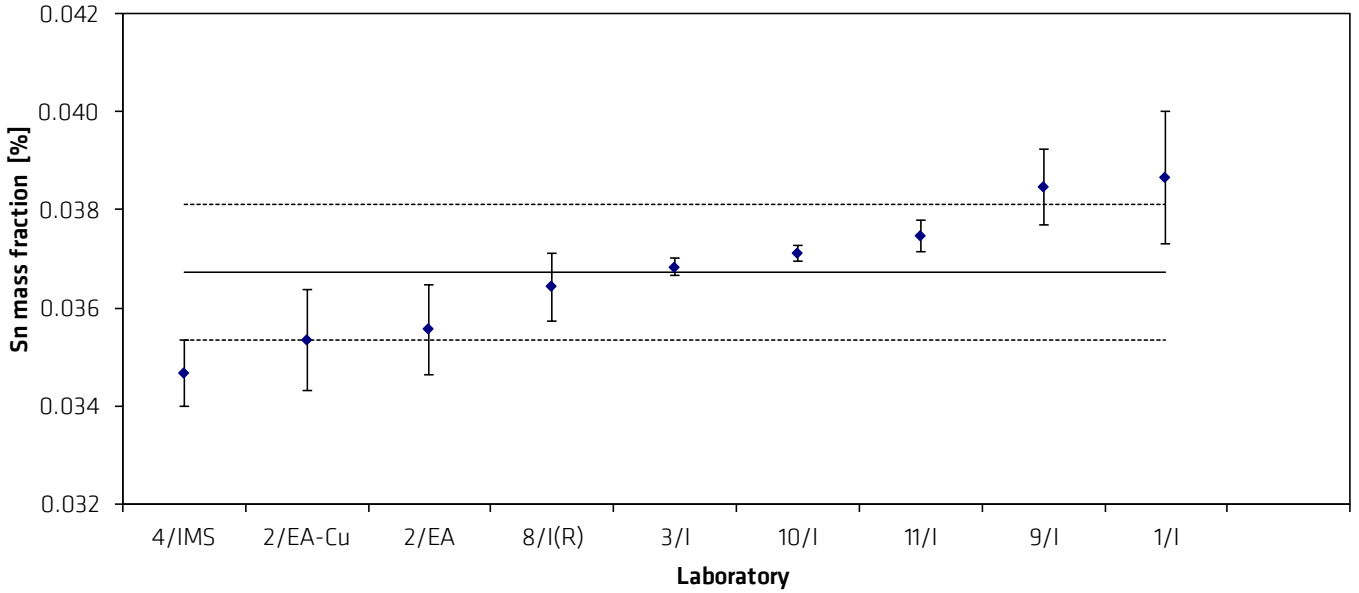


Table 6: Results for Al

Lab./Meth.	10/I	11/I	2/A	3/I	1/I	8/I	9/I	4/I		
M_i [%]	0.2082	0.2128	0.2165	0.2180	0.2218	0.2235	0.2372	0.2400		*n*
	0.2082	0.2142	0.2148	0.2179	0.2081	0.2267	0.2394	0.2480		8
	0.2090	0.2131	0.2132	0.2177	0.2211	0.2253	0.2364	0.2473		
	0.2084	0.2129	0.2130	0.2185	0.2197	0.2260	0.2408	0.2480		
	0.2085	0.2130	0.2129	0.2177	0.2258	0.2261	0.2356	0.2464		
	0.2081	0.2134	0.2127	0.2175	0.2225	0.2264	0.2402	0.2462		
***M* [%]**	**0.2084**	**0.2132**	**0.2139**	**0.2179**	**0.2198**	**0.2257**	**0.2383**	**0.2460**		**0.2229**
s[%]	0.0003	0.0005	0.0015	0.0003	0.0061	0.0012	0.0022	0.0030		0.0131
									s_M [%]	0.0026
s_{rel}	0.0016	0.0024	0.0070	0.0016	0.0277	0.0051	0.0090	0.0123	$\bar{s}_i$ [%]	0.059

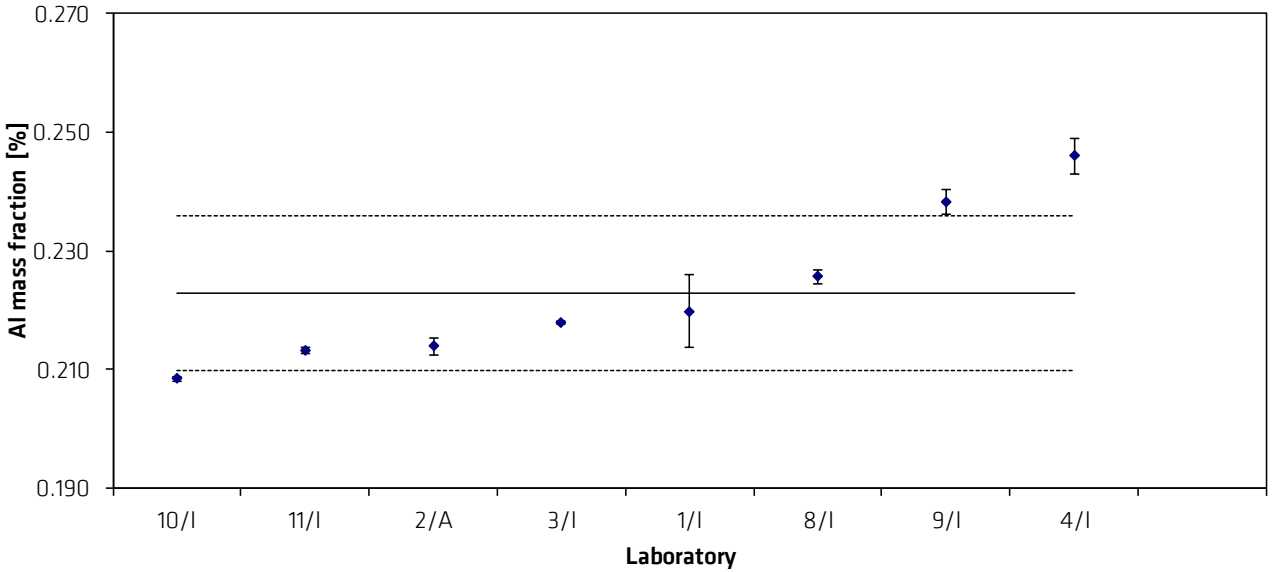


Table 7: Results for As

Lab./Meth.	2/EA	8/I	3/I	1/I	11/I	4/I	10/I	9/I		
M_i [%]	0.054	0.0559	0.0578	0.0598	0.0593	0.0600	0.0603	0.0608		*n*
	0.056	0.0562	0.0570	0.0570	0.0602	0.0608	0.0610	0.0603		8
	0.055	0.0566	0.0584	0.0598	0.0598	0.0605	0.0615	0.0618		
	0.058	0.0565	0.0582	0.0601	0.0600	0.0608	0.0616	0.0621		
	0.057	0.0568	0.0583	0.0589	0.0595	0.0604	0.0594	0.0630		
	0.056	0.0568	0.0583	0.0579	0.0603	0.0605	0.0596	0.0630		
M [%]	**0.0560**	**0.0565**	**0.0580**	**0.0589**	**0.0598**	**0.0605**	**0.0606**	**0.0618**		**0.0590**
s[%]	0.0014	0.0004	0.0006	0.0012	0.0004	0.0003	0.0009	0.0011		0.0021
									s_M [%]	0.0009
s_{rel}	0.0253	0.0063	0.0096	0.0210	0.0064	0.0049	0.0157	0.0180	$\bar{s}_i$ [%]	0.035

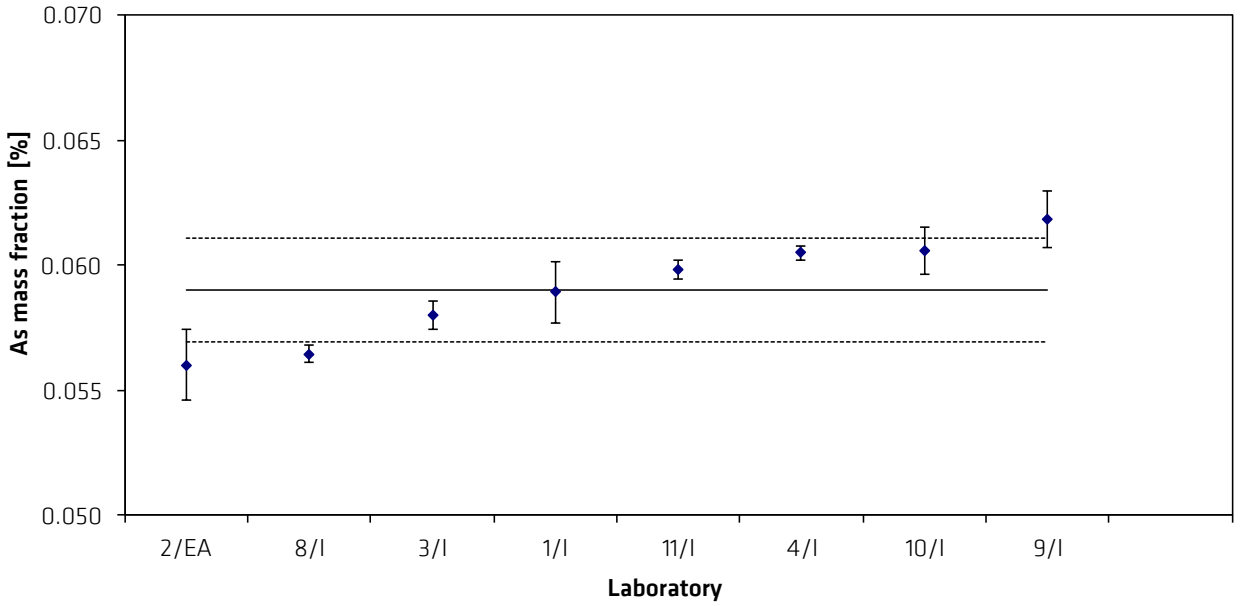


Table 8: Results for Si

Lab./Meth.	4/I	10/I	2/G	11/I	1/I	9/I	8/G		
EW [%]	0.174	0.182	0.186	0.184	0.191	0.194	0.200		*n*
	0.171	0.181	0.180	0.186	0.185	0.191	0.202		7
	0.173	0.181	0.185	0.187	0.194	0.194	0.202		
	0.175	0.180	0.183	0.187	0.192	0.195	0.199		
	0.174	0.181	0.179	0.189	0.190	0.197	0.199		
	0.174	0.182		0.191	0.189	0.197	0.200		
MW [%]	**0.173**	**0.181**	**0.182**	**0.187**	**0.190**	**0.195**	**0.200**		**0.187**
s[%]	0.0012	0.0009	0.0031	0.0024	0.0031	0.0023	0.0015		0.009
								s_M [%]	0.002
s_{rel}	0.0071	0.0047	0.0169	0.0129	0.0165	0.0116	0.0075	$\bar{s}_i$ [%]	0.048

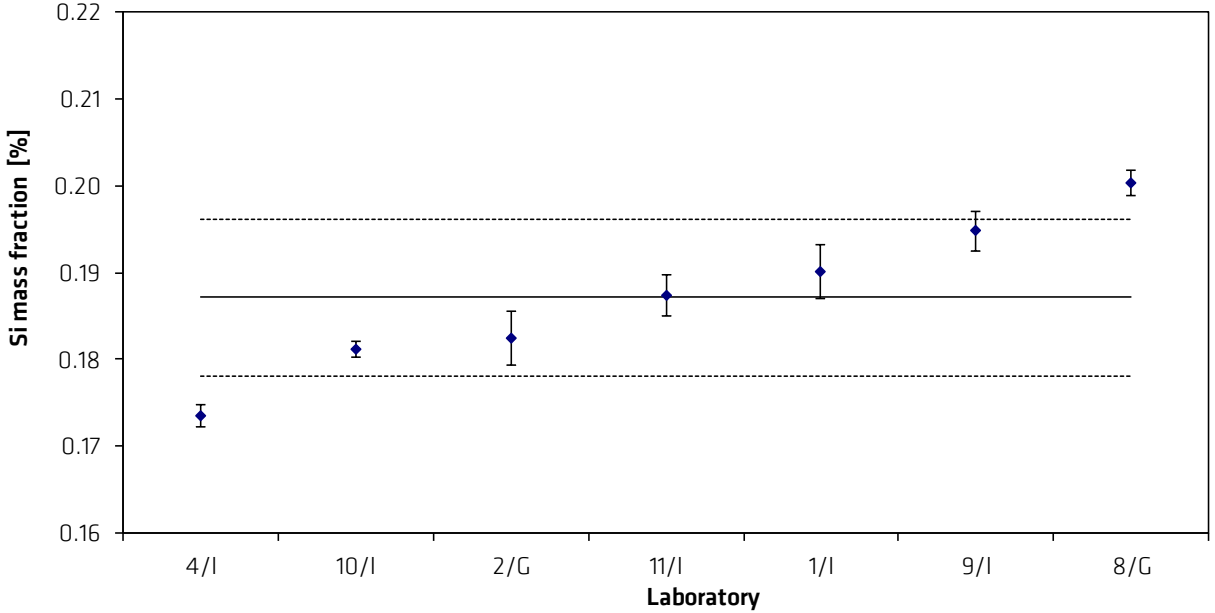


Table 9: Results for Bi

Lab./Meth.	10/I	1/EA	8/EA	4/IMS	11/I	2/EA	3/I		
M_i [mg/kg]	2.4	3.0	3	2.9	3.3	3.51	3.8		*n*
	2.7	2.8	3	3.2	3.1	3.56	3.7		7
	3.2	3.3	3	3.1	3.0	3.38	4.0		
	3.1	2.9	3	3.1	3.4	3.40	4.2		
	3.0	3.0	3	3.0	3.1	3.39	3.7		
	2.6	2.9	3	2.8	3.5	3.40	3.6		
M [mg/kg]	**2.83**	**2.99**	**3.00**	**3.01**	**3.23**	**3.44**	**3.83**		**3.19**
s[mg/kg]	0.314	0.168	0.000	0.137	0.197	0.076	0.225		0.345
								s_M [%]	0.1978
s_{rel}	0.111	0.056	0.000	0.045	0.061	0.022	0.059	$\bar{s}_i$ [%]	0.108

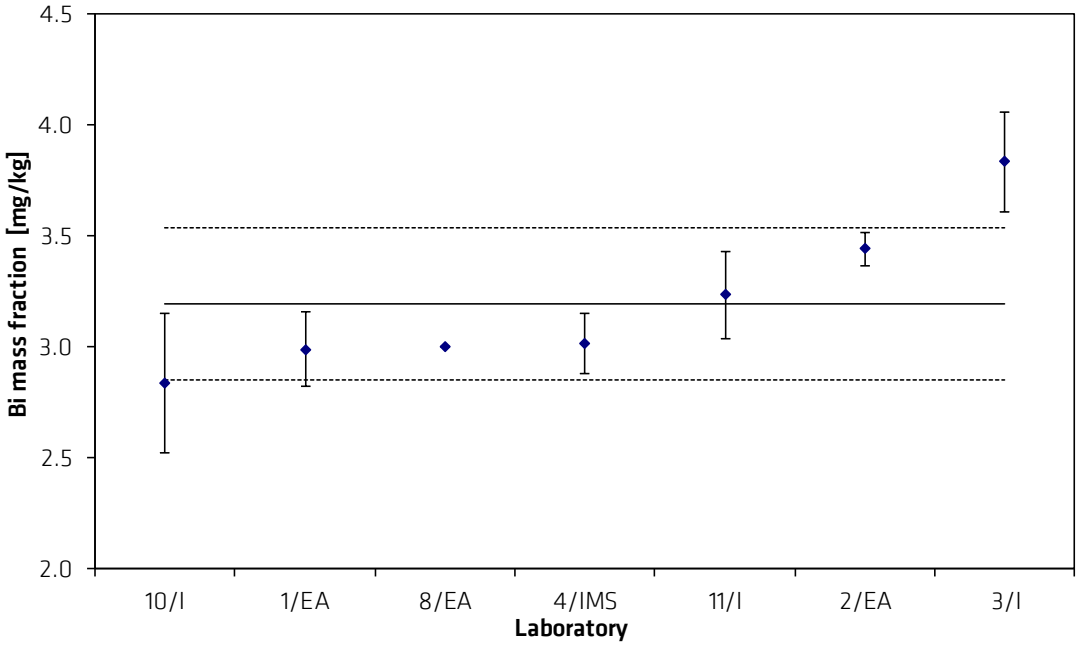


Table 10: Results for Cd

Lab./Meth.	10/I	8/I	4/IMS	1/EA	11/I	2/EA	3/I		
M_i [mg/kg]	1.8	2	2.0	2.10	2.31	2.46	2.5		*n*
	1.9	2	2.1	2.14	2.33	2.58	2.5		7
	2.2	2	2.0	2.13	2.28	2.45	2.4		
	2.3	2	2.0	2.10	2.29	2.43	2.6		
	1.9	2	2.0	2.13	2.27	2.43	2.5		
	1.8	2	2.1	2.05	2.29	2.46	2.5		
***M* [mg/kg]**	**1.98**	**2.00**	**2.01**	**2.11**	**2.30**	**2.47**	**2.50**		**2.19**
s[mg/kg]	0.214	0.000	0.037	0.033	0.022	0.056	0.052		0.223
								s_M [%]	0.100
s_{rel}	0.1077	0.0000	0.0186	0.0157	0.0094	0.0228	0.0210	$\bar{s}_i$ [%]	0.102

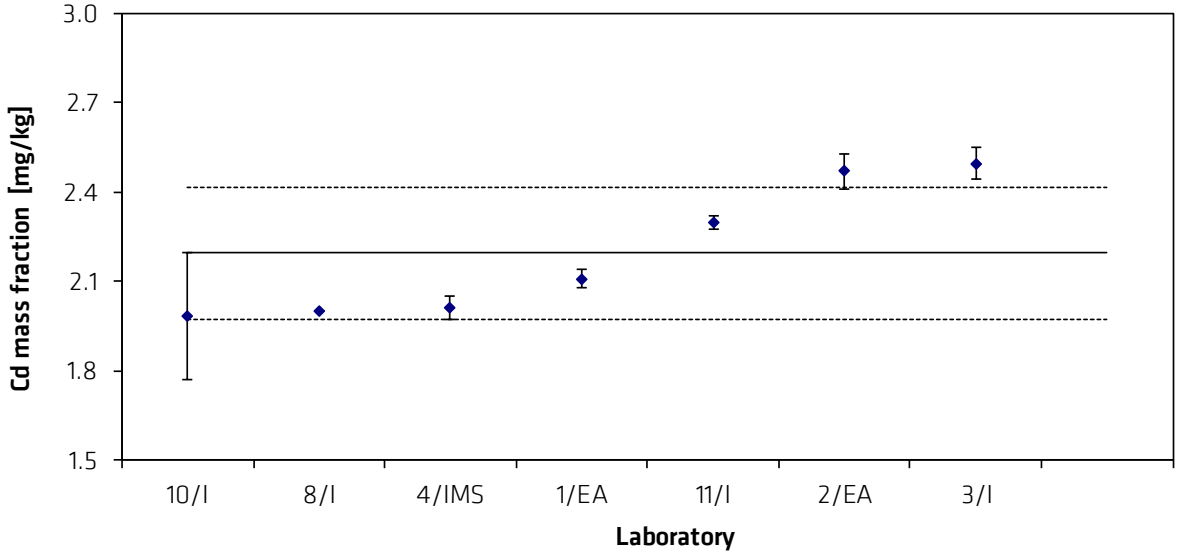


Table 11: Results for Co

Lab./Meth.	10/I(R)	8/I	2/EA	3/I	4/IMS	11/I	1/EA		
M_i [mg/kg]	1.3	1.1	1.19	1.1	1.2	1.27	1.3		*n*
	1.1	1.1	1.08	1.2	1.2	1.32	1.3		7
	0.9	1.0	1.08	1.1	1.2	1.17	1.2		
	1.2	1.1	1.08	1.1	1.2	1.25	1.2		
	0.9	1.1	1.10	1.1	1.2	1.22	1.2		
	1.0	1.1	1.11	1.1	1.2	1.23	1.3		
M [mg/kg]	**1.07**	**1.08**	**1.11**	**1.14**	**1.20**	**1.24**	**1.25**		**1.15**
s[mg/kg]	0.163	0.041	0.043	0.010	0.012	0.050	0.012		0.075
								s_M [%]	0.069
s_{rel}	0.1531	0.0377	0.0386	0.0091	0.0101	0.0406	0.0097	$\bar{s}_i$ [%]	0.065

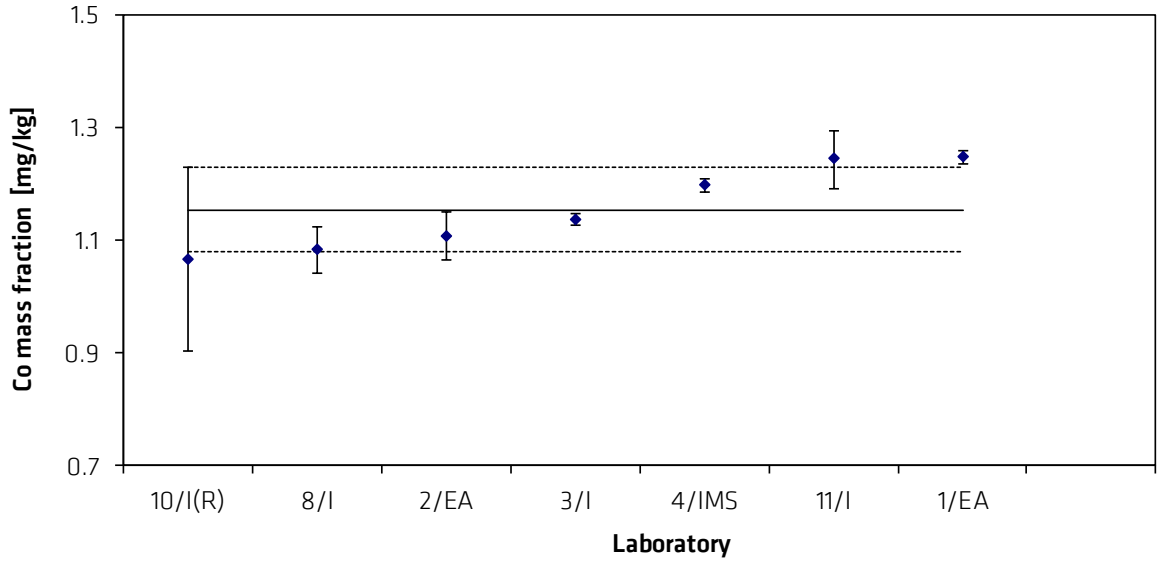


Table 12: Results for Cr

Lab./Meth.	2/EA	4/IMS	10/I	11/I	8/I	3/I	1/EA		
M_i [mg/kg]	6.23	7.46	7.7	8.37	8.2	8.44	8.69		*n*
	6.03	7.36	7.8	8.52	8.3	8.52	8.70		7
	6.10	6.98	7.9	8.28	9.1	8.60	8.62		
	7.25	7.14	7.0	8.69	8.1	8.60	8.73		
	6.65	7.86	7.7	8.26	9.2	9.15	8.58		
	6.08	7.16	7.6	8.64	7.9	8.54	8.69		
M [mg/kg]	**6.39**	**7.33**	**7.62**	**8.46**	**8.47**	**8.64**	**8.67**		**7.94**
s[mg/kg]	0.478	0.312	0.319	0.184	0.547	0.256	0.056		0.862
								s_M [%]	0.344
s_{rel}	0.0748	0.0426	0.0419	0.0218	0.0645	0.0296	0.0065	$\bar{s}_i$ [%]	0.109

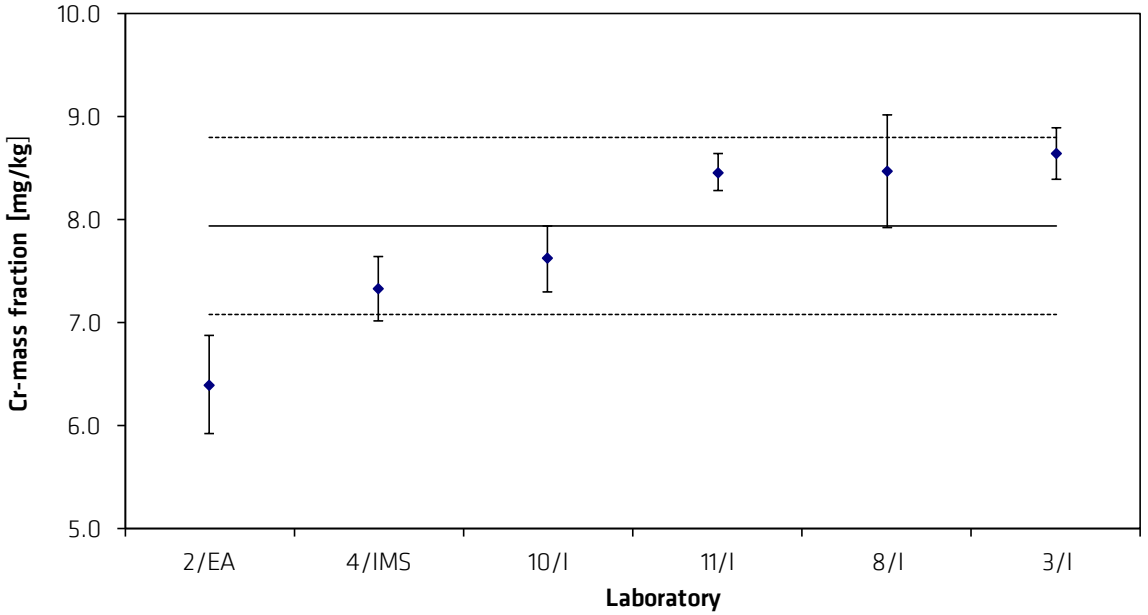


Table 13: Results for Mn

Lab./Meth.	9/I	3/I	10/I	2/A(R)	8/I	11/I	1/I	4/I		
M_i [mg/kg]	42	42.0	42	44.1	44.3	44.7	47.6	49.8		*n*
	41	42.2	43	44.6	44.3	45.0	44.3	47.7		8
	41	42.3	43	44.6	44.1	44.8	47.1	50.8		
	42	42.0	42	43.8	44.2	44.6	47.1	47.5		
	43	42.3	43	44.1	43.9	44.4	49.4	48.9		
	43	42.2	43	43.4	44.0	45.1	48.6	48.5		
M [mg/kg]	**42.00**	**42.17**	**42.67**	**44.10**	**44.13**	**44.77**	**47.35**	**48.87**		**44.51**
s[mg/kg]	0.894	0.125	0.516	0.465	0.163	0.258	1.770	1.263		2.467
									s_M [%]	0.934
s_{rel}	0.0213	0.0030	0.0121	0.0105	0.0037	0.0058	0.0374	0.0258	$\bar{s}_i$ [%]	0.055

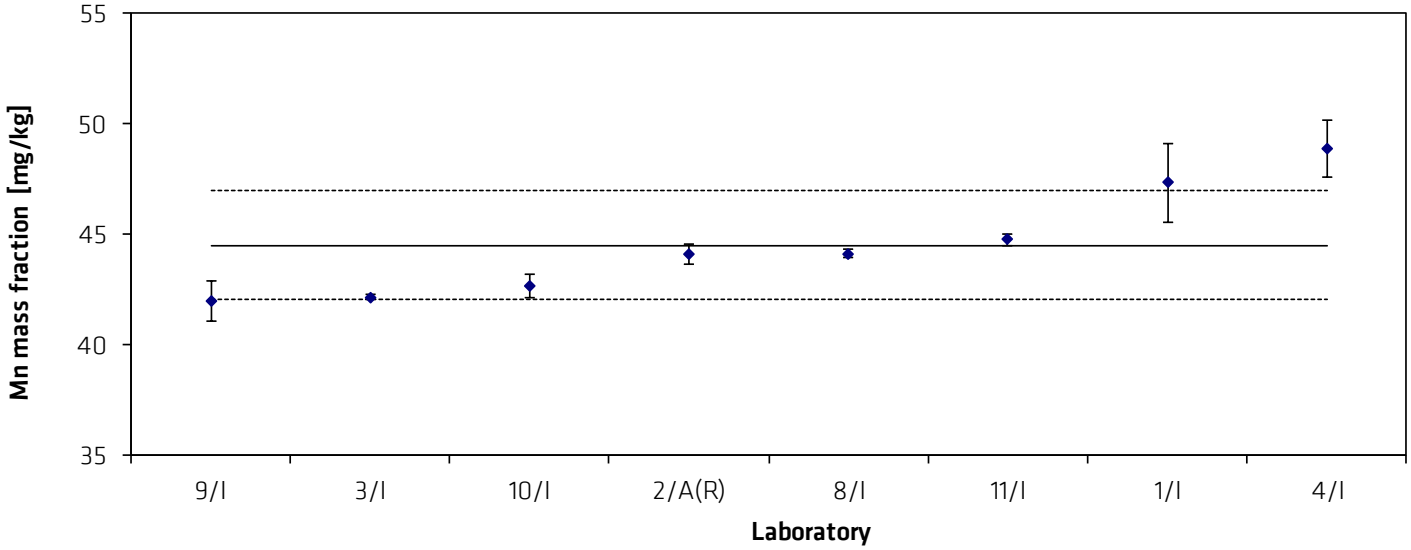


Table 14: Results for Ni

Lab./Meth.	4/IMS	9/I	3/I	8/I	2/A	10/I	11/I	1/I		
M_i [mg/kg]	129	131	140.7	144	142.4	144	150.1	154		*n*
	142	131	142.3	141	144.2	143	151.3	150		8
	128	141	140.4	140	140.6	142	147.7	155		
	126	139	142.8	146	140.2	145	151.3	156		
	133	140	141.9	138	141.6	146	149.7	157		
	134	142	141.1	141	143.0	142	150.9	155		
M [mg/kg]	**132.0**	**137.3**	**141.5**	**141.7**	**142.0**	**143.7**	**150.2**	**154.4**		**142.8**
s[mg/kg]	5.76	5.01	0.95	2.88	1.51	1.63	1.37	2.28		6.97
									s_M [%]	3.152
s_{rel}	0.0437	0.0365	0.0067	0.0203	0.0106	0.0114	0.0091	0.0148	$\bar{s}_i$ [%]	0.049

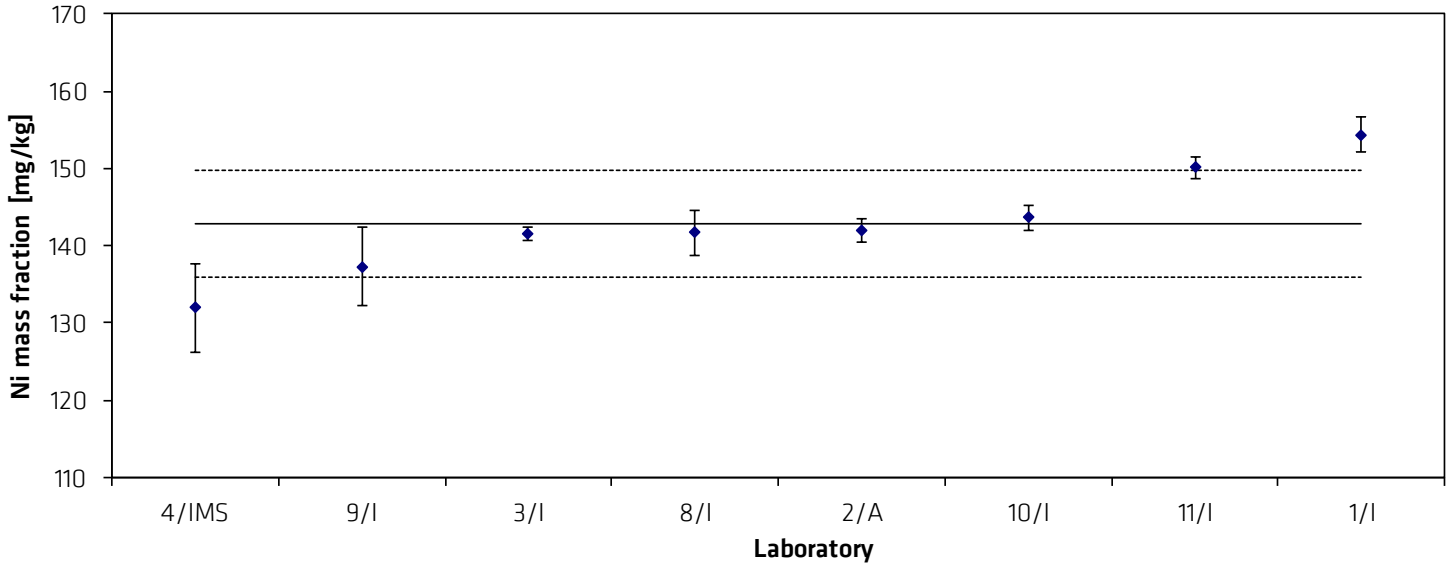


Table 15: Results for P

Lab./Meth.	11/I	10/I	1/I	8/I(R)	3/I	2/P		
M_i [mg/kg]	8.6	7.6	9.9	9.4	9.1	10.8		*n*
	7.5	7.8	8.0	7.2	8.9	11.0		6
	8.0	8.7	8.2	10.2	8.6	10.8		
	8.1	8.3	8.7	9.1	9.1	10.2		
	8.3	8.6	8.0	7.7	8.7	11.2		
	8.0	8.3	8.2	9.3	9.0	10.7		
M [mg/kg]	**8.1**	**8.2**	**8.5**	**8.8**	**8.9**	**10.8**		**8.88**
s[mg/kg]	0.366	0.436	0.728	1.134	0.192	0.335		0.978
							s_M [%]	0.532
s_{rel}	0.045	0.053	0.085	0.129	0.022	0.031	$\bar{s}_i$ [%]	0.110

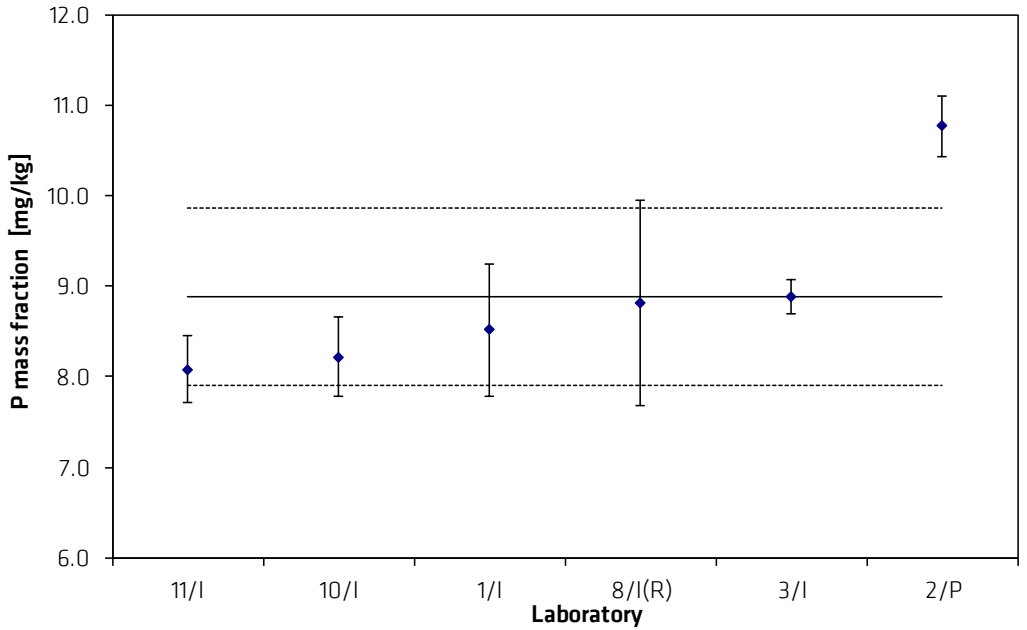


Table 16: Results for Sb

Lab./Meth.	3/I	2/EA	11/I	4/IMS	1/EA	10/I	8/EA		
M_i [mg/kg]	5.1	5.0	6.2	5.92	6.9	6.7	7		*n*
	4.7	4.8	6.5	6.08	6.7	5.9	7		7
	5.0	5.4	5.6	6.05	6.7	6.2	8		
	5.3	5.1	5.8	6.10	6.5	7.6	7		
	4.3	4.7	5.1	5.90	6.3	7.7	7		
	5.2	4.9	6.4	6.00	5.7	6.2	8		
M [mg/kg]	**4.92**	**4.97**	**5.93**	**6.01**	**6.46**	**6.72**	**7.33**		**6.05**
s[mg/kg]	0.38	0.25	0.54	0.08	0.41	0.77	0.52		0.89
								s_M [%]	0.4669
s_{rel}	0.077	0.050	0.090	0.014	0.064	0.114	0.070	$\bar{s}_i$ [%]	0.147

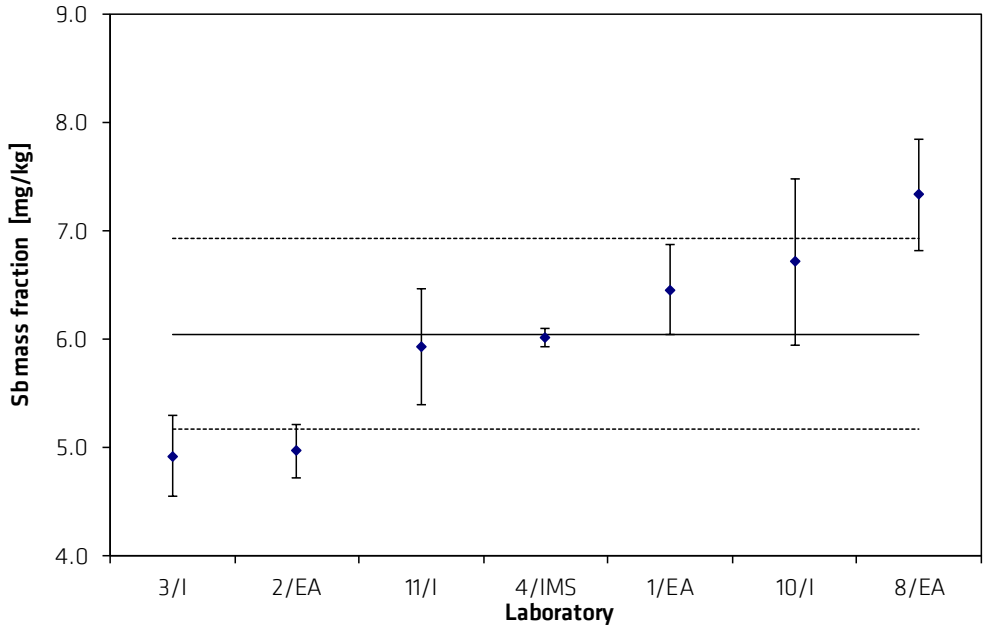
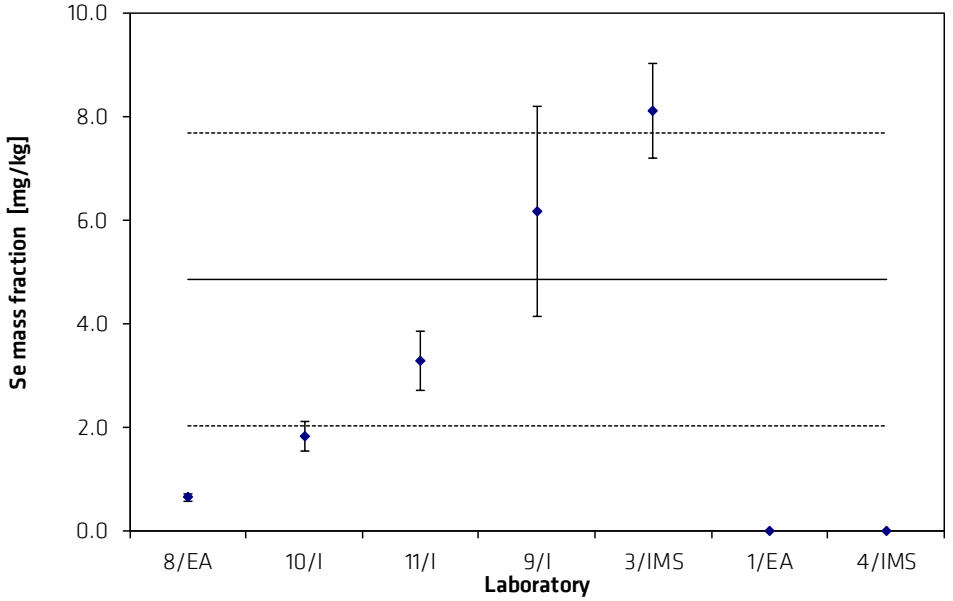


Table 17: Results for Se

Lab./Meth.	8/EA	10/I	11/I	9/I	3/IMS	1/EA	4/IMS		
M_i [mg/kg]	0.5	1.60	4.1	4	9.6	< 1	< 10		*n*
	0.7	2.20	3.3	4	8.6	< 1	< 10		5
	0.7	1.50	2.9	6	8.2	< 1	< 10		
	0.6	1.90	3.4	6	7.0	< 1	< 10		
	0.7	2.10	2.4	9	7.8	< 1	< 10		
	0.6	1.60	3.5	8	7.5	< 1	< 10		
M [mg/kg]	**0.63**	**1.82**	**3.27**	**6.17**	**8.12**	**< 1**	**< 10**		**4.84**
s[mg/kg]	0.082	0.293	0.575	2.041	0.913				2.835
								s_M [%]	0.8802
s_{rel}	0.129	0.161	0.176	0.331	0.112			$\bar{s}_i$ [%]	0.586



The statistical evaluation of the data was performed using the software program SoftCRM 1.2.2. [4]. The following results were obtained:

Tab. 18: Outcome of statistical tests on the results obtained for Cu and Pb

	Cu	Pb
Number of data sets	8	8
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Nalimov (α = 0.05)	---	---
Nalimov (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran	---	---
Kolmogorov-Smirnov-Lilliefors Test (α = 0.05)	Distribution: normal	Distribution: normal
Kolmogorov-Smirnov-Lilliefors Test (α = 0.01)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.05)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.01)	Distribution: normal	Distribution: normal

Tab. 19: Outcome of statistical tests on the results obtained for Al and Si

	Al	Si
Number of data sets	8	7
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Nalimov (α = 0.05)	Lab. 4	---
Nalimov (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran	---	---
Kolmogorov-Smirnov-Lilliefors Test (α = 0.05)	Distribution: normal	Distribution: not normal
Kolmogorov-Smirnov-Lilliefors Test (α = 0.01)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.05)	Distribution: normal	Distribution: not normal
Skewness & Kurtosis Test (α = 0.01)	Distribution: normal	Distribution: normal

The straggler (Lab. 4; Al) was not removed.

Tab. 20: Outcome of statistical tests on the results obtained for Fe and Sn

	Fe	Sn
Number of data sets	8	9
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Nalimov (α = 0.05)	---	---
Nalimov (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran	---	---
Kolmogorov-Smirnov-Lilliefors Test (α = 0.05)	Distribution: normal	Distribution: normal
Kolmogorov-Smirnov-Lilliefors Test (α = 0.01)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.05)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.01)	Distribution: normal	Distribution: normal

Tab. 21: Outcome of statistical tests on the results obtained for Mn and Ni

	Mn	Ni
Number of data sets	8	8
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Nalimov (α = 0.05)	Lab. 4	---
Nalimov (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran	---	---
Kolmogorov-Smirnov-Lilliefors Test (α = 0.05)	Distribution: normal	Distribution: normal
Kolmogorov-Smirnov-Lilliefors Test (α = 0.01)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.05)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.01)	Distribution: normal	Distribution: normal

The straggler (Lab. 4; Mn) was not removed.

Tab. 22: Outcome of statistical tests on the results obtained for As and P

	As	P
Number of data sets	8	6
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	Lab. 2
Nalimov (α = 0.05)	---	Lab. 2
Nalimov (α = 0.01)	---	Lab. 2
Grubbs (α = 0.05)	---	Lab. 2
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran	---	---
Kolmogorov-Smirnov-Lilliefors Test (α = 0.05)	Distribution: normal	Distribution: not normal
Kolmogorov-Smirnov-Lilliefors Test (α = 0.01)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.05)	Distribution: normal	Insufficient data
Skewness & Kurtosis Test (α = 0.01)	Distribution: normal	Insufficient data

The outlier (Lab. 2; P) was not removed.

Tab. 23: Outcome of statistical tests on the results obtained for Sb and Se ("<"-values were not considered)

	Sb	Se
Number of data sets	7	5
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Nalimov (α = 0.05)	---	---
Nalimov (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran	---	---
Kolmogorov-Smirnov-Lilliefors Test (α = 0.05)	Distribution: normal	Distribution: normal
Kolmogorov-Smirnov-Lilliefors Test (α = 0.01)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.05)	Distribution: normal	Insufficient data
Skewness & Kurtosis Test (α = 0.01)	Distribution: normal	Insufficient data

Tab. 24: Outcome of statistical tests on the results obtained for Bi and Cd

	Bi	Cd
Number of data sets	7	7
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Nalimov (α = 0.05)	---	---
Nalimov (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran	---	---
Kolmogorov-Smirnov-Lilliefors Test (α = 0.05)	Distribution: normal	Distribution: normal
Kolmogorov-Smirnov-Lilliefors Test (α = 0.01)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.05)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.01)	Distribution: normal	Distribution: normal

Tab. 25: Outcome of statistical tests on the results obtained for Co and Cr

	Co	Cr
Number of data sets	7	7
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Nalimov (α = 0.05)	---	Lab. 2
Nalimov (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran	---	---
Kolmogorov-Smirnov-Lilliefors Test (α = 0.05)	Distribution: normal	Distribution: normal
Kolmogorov-Smirnov-Lilliefors Test (α = 0.01)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.05)	Distribution: normal	Distribution: normal
Skewness & Kurtosis Test (α = 0.01)	Distribution: normal	Distribution: normal

The straggler (Lab. 2; Cr) was not removed.

The resp. combined uncertainties were calculated from the spread resulting from the certification inter-laboratory comparison (u_{ilc}) and the uncertainty contributions from possible inhomogeneity of the material using Equation 3.

$$u_{\text{combined}} = \sqrt{u_{ilc}^2 + u_{bb}^2(1) + u_{bb}^2(2)} \qquad (3)$$

with

$u_{ilc} = \sqrt{\frac{s_M^2}{n}}$: uncertainty contribution resulting from inter-laboratory comparison

n : number of data sets used for calculating the certified mass fraction of each element

Table 26: Uncertainty calculation (u_{bb}(rel) with the data from the homogeneity test and used for the calculation of u_{bb}(2) and u_{bb}(2) by multiplication with M)

	uncertainty contribution from									u_{bb} (rel)	
	M	n	s_M	u_{ilc}	u_{bb} (1) Length	u_{bb} (2) Area	u(comb)	U		Length	Area
	%		%	%	%	%	%	%			
Cu	65.4900	8	0.0600	0.0212	0.0543	0.0000	0.0583	0.1167		0.0830	
Pb	0.5920	8	0.0180	0.0064	0.0024	0.0017	0.0070	0.0140		0.3974	0.2901
Fe	0.0235	8	0.0016	0.0006	0.0001	0.0002	0.0006	0.00120		0.3648	0.8018
Sn	0.0367	9	0.0014	0.0005	0.0001	0.0002	0.0005	0.00103		0.1626	0.5854
Al	0.2230	8	0.0140	0.0049	0.0002	0.0003	0.0050	0.0099		0.1049	0.1353
As	0.0590	8	0.0021	0.0007	0.0001	0.0001	0.0008	0.00152		0.1687	0.1978
Si	0.1870	7	0.0090	0.0034	0.0003	0.0011	0.0036	0.0072		0.1788	0.5861
	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg			
Bi	3.2	8	0.35	0.1237	0.0360	0.0694	0.1464	0.2927		1.1283	2.1747
Cd	2.19	7	0.02	0.0084	0.0115	0.0492	0.0512	0.1025		0.5245	2.2476
Co	1.15	7	0.08	0.0283	0.0100	0.0110	0.0320	0.0640		0.8731	0.9555
Cr	7.94	7	0.86	0.3258	0.0192	0.0585	0.3316	0.6631		0.2419	0.7368
Mn	44.5	8	2.50	0.8839	0.1106	0.2217	0.9180	1.8359		0.2484	0.4983
Ni	142.90	8	6.97	2.4643	5.8239	5.0224	8.076	16.151		4.0755	3.5146
P	8.9	6	0.98	0.3993	0.0739	0.1987	0.4521	0.9041		0.8327	2.2376
Sb	6.05	7	0.89	0.3364	0.0146	0.0446	0.3396	0.6793		0.2419	0.7368

The expanded uncertainties U were calculated by multiplication of $u_{combined}$ with a coverage factor of k = 2 using Equation 4.

$$U = k \cdot u_{\text{combined}} \qquad (4)$$

The calculated mass fractions and their respective expanded uncertainties are given on Page 3 of this report.
Rounding was done according to DIN 1333 [5].

In addition to the wet chemical characterisation an accompanying inter-laboratory comparison with spark emission was performed to check if there is agreement between SOES/XRF and wet chemistry. Three additional laboratories participated in this comparison. Tab. 27 shows the mean values of wet chemical and SOES/XRF results as well as their standard deviations. The agreement between wet chemistry and SOES/XRF is good for all elements except of Bi where the results obtained with SOES have a very wide spread. There were no suitable results for Co, Cr and Sb from the SOES/XRF inter-laboratory comparison.

Tab. 27: Comparison wet chemistry vs. SOES/XRF

Element	Wet chemical analysis			Spark emission		
	Mass fraction in %	**Std.-dev.** in %	***n***	**Mass fraction** in %	**Std.-dev.** in %	***n***
Cu	65.49	0.06	8	65.34	0.87	11
Pb	0.592	0.018	8	0.591	0.030	13
Fe	0.0235	0.0016	8	0.0226	0.0026	12
Sn	0.0367	0.0014	9	0.0368	0.0036	11
Al	0.223	0.014	8	0.214	0.022	13
As	0.0590	0.0021	8	0.0588	0.0059	12
Si	0.187	0.009	7	0.177	0.015	13
	in mg/kg	in mg/kg		in mg/kg	in mg/kg	
Bi	3.2	0.4	7	7.2	4.1	5
Cd	2.19	0.23	7	2.12	0.88	2
Co	1.15	0.08	7			
Cr	7.9	0.9	7			
Mn	44.5	2.5	8	52.4	10.0	11
Ni	143	7	8	150	20	11
P	8.9	1.0	6	9.8	3.2	5
Sb	6.1	0.9	7			

6. Instructions for users and stability statement

The certified reference material BAM-M396 is intended for the calibration and quality control of spark emission and X-ray fluorescence spectrometry used for the analysis of similar materials. It can also be used for wet chemical analysis.
Before analysis the surface of the material should be cleaned by turning or milling. The preparation of the surface has to be done slowly to avoid heating of the disc.
If chips prepared from the compact material are used for wet chemical analysis, a minimum sample intake of 0.2 g should be used.
The material will remain stable provided that it is not subjected to excessive heat (e.g., during preparation of the working surface).
An area of 8mm in diameter in the centre of the discs should be avoided for spark optical emission spectrometry.

7. Metrological Traceability

The ensure traceable of the certified mass fractions to the SI (Système International d'Unités) calibration was done using standard solutions prepared from pure metals or stoichiometric compounds or well checked commercial calibration solutions.

8. Information on and purchase of the CRM

Certified reference material BAM-M396 is supplied by
Bundesanstalt für Materialforschung und -prüfung (BAM)
Division 1.6 „Inorganic Reference Materials“
Richard-Willstätter-Str. 11, D-12489 Berlin, Germany
Phone +49 (0)30 - 8104 2061
Fax: +49 (0)30 – 8104 72061
E-Mail: sales.crm@bam.de

Each disc of BAM-M396 will be distributed together with a detailed certificate containing the certified values and their uncertainties, the mean values and standard deviations of all accepted data sets and information on the analytical methods used and the names of the participating laboratories.
Information on certified reference materials can be obtained from BAM:
https://www.bam.de.
Tel. +49 30 8104 1111.

9. References

[1] ISO 17034, General requirements for the competence of reference material producers, 2015

[2] ISO Guide 31, Reference materials - Contents of certificates, labels and accompanying documentation, 2015

[3] ISO Guide 35, Reference materials - General and statistical principles for certification. Third edition, 2006

[4] Bonas G, Zervou M, Papaeoannou T, Lees M: Accred Qual Assur (2003) 8:101-107

[5] DIN 1333:1992-02 Zahlenangaben

Annex 1: Calculation of uncertainty contribution of potential inhomogeneity (length)

Copper:

M396-A1E	63.113
M396-A1E	63.141
M396-A2E	63.128
M396-A2E	63.172
M396-A3E	63.158
M396-A3E	63.189
M396-B1A	63.17
M396-B1A	63.201
M396-B1E	63.191
M396-B1E	63.17
M396-B2E	62.894
M396-B2E	62.949
M396-B3E	63.124
M396-B3E	63.171
M396-C1A	63.167
M396-C1A	63.157
M396-C1E	63.145
M396-C1E	63.148
M396-C2E	63.134
M396-C2E	63.142
M396-C3E	63.145
M396-C3E	63.148
M396-D1A	63.139
M396-D1A	63.163
M396-D1E	63.183
M396-D1E	63.142
M396-D2E	63.166
M396-D2E	63.186
M396-D3E	63.219
M396-D3E	63.166
M396-E1A	63.137
M396-E1A	63.197
M396-E1E	63.162
M396-E1E	63.153
M396-E2E	63.172
M396-E2E	63.136
M396-E3E	63.173
M396-E3E	63.161

Mean	63.149
s	0.059884147
Min.	62.894
Max.	63.287
s(rel.)	0.094829922
Mean (instrument)	63.2269
s(instrument)	0.028992145
s(rel.)	0.045854129
s - s(instrument)	0.052398155
s',rel	0.082975431

Lead:

	1	2	3	4	5	6
A1A	0.563051	0.56037	0.555385	0.540554	0.553248	0.546894
A1E	0.593995	0.555374	0.545834	0.549184	0.551039	0.549325
A2E	0.560381	0.561418	0.552812	0.547391	0.553655	0.543768
A3E	0.590005	0.562309	0.551736	0.551621	0.542579	0.544275
B1A	0.579769	0.556016	0.540143	0.547094	0.545182	0.530329
B1E	0.560729	0.554665	0.543707	0.54961	0.546412	0.551592
B2E	0.560055	0.553697	0.54697	0.544287	0.541315	0.547044
B3E	0.558594	0.562148	0.548618	0.552901	0.546944	0.545185
C1A	0.562116	0.560025	0.548969	0.546253	0.542198	0.555397
C1E	0.590973	0.557755	0.555973	0.551175	0.546198	0.539766
C2E	0.564106	0.557637	0.549263	0.548386	0.545772	0.541658
C3E	0.560904	0.558155	0.55029	0.546175	0.546633	0.537038
D1A	0.58537	0.55497	0.546972	0.542933	0.544918	0.541197
D1E	0.584469	0.558959	0.546692	0.545936	0.542416	0.547331
D2E	0.585445	0.55425	0.549045	0.549817	0.545525	0.541203
D3E	0.591093	0.555398	0.547865	0.544277	0.552776	0.548392
E1A	0.561205	0.560379	0.551429	0.551982	0.551763	0.548266
E1E	0.588662	0.557637	0.552749	0.543328	0.553339	0.543625
E2E	0.583934	0.562318	0.549567	0.544783	0.548572	0.535291
E3E	0.559232	0.560673	0.552178	0.550673	0.543412	0.552701

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	3.319502	0.553250333	7.05799E-05		
A1E	6	3.344751	0.5574585	0.000330044		
A2E	6	3.319425	0.5532375	4.84317E-05		
A3E	6	3.342525	0.5570875	0.000308801		
B1A	6	3.298533	0.5497555	0.000287559		
B1E	6	3.306715	0.551119167	3.69041E-05		
B2E	6	3.293368	0.548894667	4.66853E-05		
B3E	6	3.31439	0.552398333	4.59536E-05		
C1A	6	3.314958	0.552493	6.30219E-05		
C1E	6	3.34184	0.556973333	0.000320682		
C2E	6	3.306822	0.551137	6.80319E-05		
C3E	6	3.299195	0.549865833	7.58716E-05		
D1A	6	3.31636	0.552726667	0.000278712		
D1E	6	3.325803	0.5543005	0.000249902		
D2E	6	3.325285	0.554214167	0.000253243		
D3E	6	3.339801	0.5566335	0.000300271		
E1A	6	3.325024	0.554170667	2.81988E-05		
E1E	6	3.33934	0.556556667	0.000279799		
E2E	6	3.324465	0.5540775	0.000289858		
E3E	6	3.318869	0.553144833	3.91393E-05		
			0.553474758			

ANOVA

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	0.000746761	19	3.93032E-05	0.229729861	0.999678096	1.691495727
Within groups	0.017108447	100	0.000171084			
Total	0.017855208	119				

within-sd	0.013079926					
effective n	5.00					
s_bb	0					
s bb min	0.002199773					
u_bb	0.002199773	2.199772642				
u bb(rel.)	0.39744769					

Iron:

	1	2	3	4	5	6
A1A	0.026706	0.026157	0.025823	0.025517	0.025618	0.025465
A1E	0.026722	0.026213	0.025587	0.025448	0.025608	0.025416
A2E	0.026627	0.026277	0.025836	0.025384	0.025405	0.025442
A3E	0.026655	0.026359	0.026651	0.025816	0.025427	0.0255
B1A	0.026814	0.026282	0.025558	0.025715	0.025672	0.025292
B1E	0.026628	0.026403	0.025533	0.025678	0.025594	0.025627
B2E	0.026757	0.026112	0.026512	0.025353	0.025451	0.025605
B3E	0.026818	0.026549	0.025696	0.025654	0.025463	0.025385
C1A	0.026386	0.026251	0.026523	0.025245	0.025216	0.025543
C1E	0.026998	0.026125	0.025884	0.025542	0.02568	0.025284
C2E	0.026321	0.026378	0.025573	0.025607	0.025329	0.025526
C3E	0.026677	0.026087	0.026756	0.025664	0.025401	0.025307
D1A	0.026693	0.026237	0.026625	0.025577	0.025355	0.025334
D1E	0.026668	0.026364	0.026692	0.025591	0.025772	0.025178
D2E	0.026447	0.0263	0.026518	0.025445	0.025366	0.025378
D3E	0.026755	0.026344	0.025714	0.025467	0.025447	0.025412
E1A	0.026601	0.026374	0.025974	0.025627	0.025617	0.025754
E1E	0.027025	0.02619	0.025529	0.025262	0.025889	0.025432
E2E	0.026932	0.026556	0.026899	0.025625	0.025771	0.02528
E3E	0.026531	0.026256	0.025721	0.025652	0.025487	0.025612

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	0.155286	0.025881	2.26977E-07		
A1E	6	0.154994	0.025832333	2.73595E-07		
A2E	6	0.154971	0.0258285	2.73025E-07		
A3E	6	0.156408	0.026068	3.1323E-07		
B1A	6	0.155333	0.025888833	3.10682E-07		
B1E	6	0.155463	0.0259105	2.26894E-07		
B2E	6	0.15579	0.025965	3.43284E-07		
B3E	6	0.155565	0.0259275	3.63543E-07		
C1A	6	0.155164	0.025860667	3.52515E-07		
C1E	6	0.155513	0.025918833	3.62075E-07		
C2E	6	0.154734	0.025789	1.98099E-07		
C3E	6	0.155892	0.025982	3.97487E-07		
D1A	6	0.155821	0.025970167	3.92043E-07		
D1E	6	0.156265	0.026044167	3.88166E-07		
D2E	6	0.155454	0.025909	3.21062E-07		
D3E	6	0.155139	0.0258565	3.16449E-07		
E1A	6	0.155947	0.025991167	1.69524E-07		
E1E	6	0.155327	0.025887833	4.22533E-07		
E2E	6	0.157063	0.026177167	5.0182E-07		
E3E	6	0.155259	0.0258765	1.73728E-07		
			0.025928233			
ANOVA						
Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	9.72061E-07	19	5.11611E-08	0.161730077	0.999977819	1.691495727
Within groups	3.16337E-05	100	3.16337E-07			
Total	3.26057E-05	119				
within-sd	0.000562438					
effective n	5.00					
s_bb	0					
s_bb_min	9.45904E-05					
u_bb	9.45904E-05	0.094590422				
u_bb(rel.)	0.364816302					

Tin:

	1	2	3	4	5	6
A1A	0.034706	0.03496	0.034292	0.034463	0.034212	0.034344
A1E	0.03416	0.034798	0.034425	0.034361	0.034633	0.03472
A2E	0.034845	0.034703	0.034435	0.034581	0.03468	0.03466
A3E	0.034137	0.03512	0.03525	0.034392	0.03419	0.034617
B1A	0.034353	0.034722	0.034421	0.034412	0.034872	0.034474
B1E	0.035025	0.034577	0.034918	0.03454	0.034427	0.034692
B2E	0.034961	0.034825	0.035488	0.034492	0.034715	0.034479
B3E	0.034642	0.034366	0.034253	0.034237	0.034556	0.034399
C1A	0.034847	0.03445	0.035347	0.0341	0.03457	0.034233
C1E	0.033971	0.034992	0.034497	0.034137	0.034668	0.034745
C2E	0.034936	0.034952	0.034742	0.034625	0.0346	0.034756
C3E	0.034499	0.034953	0.035327	0.034683	0.034674	0.0347
D1A	0.034104	0.034645	0.03549	0.0348	0.034147	0.034429
D1E	0.033939	0.034432	0.035164	0.034243	0.034252	0.034387
D2E	0.033983	0.034624	0.035407	0.034345	0.034247	0.034556
D3E	0.034152	0.034614	0.03462	0.034509	0.034479	0.034451
E1A	0.034783	0.034607	0.034458	0.034407	0.034445	0.034432
E1E	0.034393	0.034798	0.034669	0.034426	0.034494	0.034554
E2E	0.033854	0.034189	0.035584	0.034233	0.034554	0.034509
E3E	0.034762	0.034491	0.034417	0.034482	0.034282	0.03429

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	0.206977	0.034496167	8.11722E-08		
A1E	6	0.207097	0.034516167	5.87742E-08		
A2E	6	0.207904	0.034650667	1.85635E-08		
A3E	6	0.207706	0.034617667	2.2341E-07		
B1A	6	0.207254	0.034542333	4.26371E-08		
B1E	6	0.208179	0.0346965	5.36795E-08		
B2E	6	0.20896	0.034826667	1.40151E-07		
B3E	6	0.206453	0.034408833	2.63534E-08		
C1A	6	0.207547	0.034591167	2.05328E-07		
C1E	6	0.20701	0.034501667	1.48383E-07		
C2E	6	0.208611	0.0347685	2.23143E-08		
C3E	6	0.208836	0.034806	8.62176E-08		
D1A	6	0.207615	0.0346025	2.62911E-07		
D1E	6	0.206417	0.034402833	1.68783E-07		
D2E	6	0.207162	0.034527	2.38422E-07		
D3E	6	0.206825	0.034470833	2.92638E-08		
E1A	6	0.207132	0.034522	2.13392E-08		
E1E	6	0.207334	0.034555667	2.37299E-08		
E2E	6	0.206923	0.034487167	3.52478E-07		
E3E	6	0.206724	0.034454	3.09732E-08		
			0.034572217			

ANOVA

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.73626E-06	19	9.13822E-08	0.817780776	0.681421238	1.691495727
Within groups	1.11744E-05	100	1.11744E-07			
Total	1.29107E-05	119				

within-sd	0.000334282	
effective n	5.00	
s_bb	0	
s_bb_min	5.62192E-05	
u_bb	5.62192E-05	0.056219229
u_bb(rel.)	0.162613896	

Aluminium:

	1	2	3	4	5	6
A1A	0.254582	0.253227	0.2517	0.251215	0.251243	0.249357
A1E	0.253707	0.252482	0.250841	0.251576	0.251995	0.251703
A2E	0.253413	0.252833	0.25258	0.25066	0.251309	0.25096
A3E	0.252683	0.253075	0.253444	0.25192	0.250243	0.249693
B1A	0.253807	0.253153	0.251113	0.251886	0.254474	0.249233
B1E	0.255232	0.254474	0.252127	0.252039	0.252238	0.252157
B2E	0.253982	0.252783	0.25314	0.250724	0.249569	0.25179
B3E	0.254116	0.253389	0.251749	0.252943	0.250544	0.250556
C1A	0.253747	0.25458	0.25359	0.250314	0.249575	0.252451
C1E	0.25416	0.253741	0.252119	0.251998	0.251939	0.249157
C2E	0.252909	0.254447	0.252144	0.251451	0.25069	0.250021
C3E	0.253121	0.252213	0.253205	0.251211	0.249894	0.249614
D1A	0.252176	0.2533	0.253801	0.250706	0.250752	0.249536
D1E	0.253554	0.253231	0.253794	0.251953	0.250933	0.249611
D2E	0.253038	0.252593	0.253624	0.253192	0.24987	0.249452
D3E	0.253923	0.253545	0.251821	0.251308	0.251072	0.251128
E1A	0.253579	0.253328	0.25183	0.252995	0.252366	0.252503
E1E	0.253716	0.253067	0.250791	0.25037	0.253735	0.250651
E2E	0.252358	0.254585	0.2544	0.251302	0.252486	0.249185
E3E	0.253594	0.253695	0.251977	0.252913	0.251357	0.251386

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	1.511324	0.251887333	3.27216E-06		
A1E	6	1.512304	0.252050667	9.48412E-07		
A2E	6	1.511755	0.251959167	1.27431E-06		
A3E	6	1.511058	0.251843	2.39501E-06		
B1A	6	1.513666	0.252277667	3.74176E-06		
B1E	6	1.518267	0.2530445	2.02391E-06		
B2E	6	1.511988	0.251998	2.68461E-06		
B3E	6	1.513297	0.252216167	2.25675E-06		
C1A	6	1.514257	0.252376167	4.06282E-06		
C1E	6	1.513114	0.252185667	3.11808E-06		
C2E	6	1.511662	0.251943667	2.54995E-06		
C3E	6	1.509258	0.251543	2.45034E-06		
D1A	6	1.510271	0.251711833	2.75391E-06		
D1E	6	1.513076	0.252179333	2.76075E-06		
D2E	6	1.511769	0.2519615	3.30153E-06		
D3E	6	1.512797	0.252132833	1.62231E-06		
E1A	6	1.516601	0.252766833	4.26903E-07		
E1E	6	1.51233	0.252055	2.60272E-06		
E2E	6	1.514316	0.252386	4.06481E-06		
E3E	6	1.514922	0.252487	1.12308E-06		
			0.252150267			
ANOVA						
Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.3826E-05	19	7.27684E-07	0.294405688	0.998163741	1.691495727
Within groups	0.000247171	100	2.47171E-06			
Total	0.000260997	119				
within-sd	0.001572166					
effective n	5.00					
s bb	0					
s bb min	0.000264406					
u bb	0.000264406	0.264405751				
u bb(rel.)	0.104860389					

Arsenic:

	1	2	3	4	5	6
A1A	0.059491	0.059274	0.060068	0.059697	0.059265	0.059359
A1E	0.058071	0.059187	0.059429	0.059815	0.059644	0.059432
A2E	0.059206	0.058534	0.0602	0.059783	0.059837	0.059747
A3E	0.058126	0.05915	0.05991	0.059532	0.059012	0.059223
B1A	0.058314	0.059229	0.059682	0.05965	0.059685	0.05935
B1E	0.059559	0.059066	0.059686	0.059406	0.059417	0.059373
B2E	0.059459	0.058974	0.060268	0.059805	0.059412	0.059182
B3E	0.059412	0.05901	0.060244	0.060148	0.059364	0.059027
C1A	0.059171	0.05862	0.059698	0.059313	0.059523	0.05902
C1E	0.057818	0.059162	0.060487	0.059741	0.06006	0.059172
C2E	0.058757	0.058743	0.05985	0.059438	0.059485	0.05921
C3E	0.05914	0.059063	0.060012	0.059954	0.059233	0.059448
D1A	0.058641	0.058872	0.060617	0.059607	0.058631	0.059519
D1E	0.05797	0.058939	0.060166	0.059086	0.058885	0.059206
D2E	0.057931	0.058654	0.060076	0.059524	0.058861	0.059294
D3E	0.058469	0.05849	0.059864	0.059721	0.059616	0.059196
E1A	0.059278	0.058585	0.059709	0.059692	0.059942	0.059009
E1E	0.05822	0.058893	0.059739	0.059511	0.059445	0.059376
E2E	0.057857	0.058664	0.060535	0.059354	0.059913	0.059326
E3E	0.059033	0.05874	0.059596	0.05992	0.058801	0.059388

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	0.357154	0.059525667	9.67487E-08		
A1E	6	0.355578	0.059263	3.86524E-07		
A2E	6	0.357307	0.059551167	3.4971E-07		
A3E	6	0.354953	0.059158833	3.59201E-07		
B1A	6	0.35591	0.059318333	2.78874E-07		
B1E	6	0.356507	0.059417833	4.35558E-08		
B2E	6	0.3571	0.059516667	2.13681E-07		
B3E	6	0.357205	0.059534167	2.91301E-07		
C1A	6	0.355345	0.059224167	1.46248E-07		
C1E	6	0.35644	0.059406667	8.68907E-07		
C2E	6	0.355483	0.059247167	1.90444E-07		
C3E	6	0.35685	0.059475	1.71814E-07		
D1A	6	0.355887	0.0593145	5.88093E-07		
D1E	6	0.354252	0.059042	4.9533E-07		
D2E	6	0.35434	0.059056667	5.56264E-07		
D3E	6	0.355356	0.059226	3.83963E-07		
E1A	6	0.356215	0.059369167	2.60159E-07		
E1E	6	0.355184	0.059197333	3.0657E-07		
E2E	6	0.355649	0.059274833	8.77506E-07		
E3E	6	0.355478	0.059246333	2.19274E-07		
			0.059318275			

ANOVA

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	2.67283E-06	19	1.40675E-07	0.397153441	0.987843889	1.691495727
Within groups	3.54208E-05	100	3.54208E-07			
Total	3.80937E-05	119				

within-sd	0.000595154	
effective n	5.00	
s_bb	0	
s_bb_min	0.000100093	
u_bb	0.000100093	0.100092586
u_bb(rel.)	0.168738194	

Silicon:

	1	2	3	4	5	6
A1A	0.187636	0.186284	0.184991	0.183464	0.183594	0.183348
A1E	0.18893	0.185328	0.184343	0.184737	0.185087	0.185238
A2E	0.186898	0.184819	0.186445	0.183835	0.184318	0.184493
A3E	0.189159	0.186419	0.187024	0.185057	0.183307	0.1829
B1A	0.190241	0.18583	0.185104	0.184735	0.18587	0.182405
B1E	0.188561	0.186577	0.185465	0.185206	0.184597	0.184078
B2E	0.187799	0.186318	0.186306	0.183732	0.182863	0.184074
B3E	0.187642	0.185192	0.18446	0.185612	0.183986	0.183909
C1A	0.186375	0.185785	0.186727	0.183513	0.183552	0.1847
C1E	0.189132	0.18557	0.185777	0.184484	0.184961	0.182395
C2E	0.186177	0.185875	0.184853	0.183928	0.18359	0.182671
C3E	0.18654	0.18547	0.187363	0.18474	0.18291	0.183017
D1A	0.18778	0.184871	0.187297	0.1837	0.182497	0.182598
D1E	0.188946	0.184734	0.186677	0.18372	0.182837	0.182922
D2E	0.188268	0.1853	0.186656	0.1856	0.183282	0.182198
D3E	0.189846	0.184819	0.184822	0.183061	0.183944	0.183666
E1A	0.187054	0.184883	0.185178	0.185403	0.18447	0.184447
E1E	0.190636	0.185271	0.185012	0.183207	0.185515	0.183775
E2E	0.188162	0.185575	0.18836	0.183543	0.185119	0.181899
E3E	0.18649	0.185762	0.184541	0.185159	0.183448	0.183739

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	1.109317	0.184886167	3.11694E-06		
A1E	6	1.113663	0.1856105	2.77625E-06		
A2E	6	1.110808	0.185134667	1.53876E-06		
A3E	6	1.113866	0.185644333	5.63918E-06		
B1A	6	1.114185	0.1856975	6.56198E-06		
B1E	6	1.114484	0.185747333	2.61755E-06		
B2E	6	1.111092	0.185182	3.6221E-06		
B3E	6	1.110801	0.1851335	1.95894E-06		
C1A	6	1.110652	0.185108667	1.96328E-06		
C1E	6	1.112319	0.1853865	4.83191E-06		
C2E	6	1.107094	0.184515667	1.86532E-06		
C3E	6	1.11004	0.185006667	3.3088E-06		
D1A	6	1.108743	0.1847905	5.2965E-06		
D1E	6	1.109836	0.184972667	5.81691E-06		
D2E	6	1.111304	0.185217333	4.8783E-06		
D3E	6	1.110158	0.185026333	6.03968E-06		
E1A	6	1.111435	0.185239167	9.34041E-07		
E1E	6	1.113416	0.185569333	6.97479E-06		
E2E	6	1.112658	0.185443	6.43884E-06		
E3E	6	1.109139	0.1848565	1.3824E-06		
			0.185208417			

ANOVA

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.27964E-05	19	6.73497E-07	0.173665558	0.999961177	1.691495727
Within groups	0.000387812	100	3.87812E-06			
Total	0.000400609	119				

within-sd	0.001969295					
effective n	5.00					
s_bb	0					
s_bb_min	0.000331195					
u_bb	0.000331195	0.331194678				
u_bb(rel.)	0.178822693					

Bismuth:

	1	2	3	4	5	6
A1A	0.000716	0.000731	0.000721	0.000647	0.000714	0.000721
A1E	0.000685	0.000669	0.000715	0.000721	0.000711	0.000689
A2E	0.000705	0.000649	0.000705	0.000668	0.000732	0.000673
A3E	0.00068	0.000674	0.00076	0.000641	0.000667	0.00066
B1A	0.000653	0.00073	0.000668	0.000685	0.000689	0.000713
B1E	0.000691	0.000711	0.000691	0.000674	0.000683	0.000674
B2E	0.000718	0.000673	0.000691	0.000664	0.000673	0.000694
B3E	0.000737	0.00072	0.000678	0.000755	0.000677	0.00073
C1A	0.00074	0.000684	0.000697	0.00073	0.000704	0.000679
C1E	0.000748	0.000698	0.00075	0.000708	0.00073	0.000684
C2E	0.000689	0.000672	0.000663	0.000706	0.000738	0.000703
C3E	0.000691	0.000701	0.000671	0.000677	0.000694	0.000631
D1A	0.000706	0.00069	0.00069	0.000648	0.000659	0.000708
D1E	0.000664	0.000717	0.000657	0.00074	0.000685	0.000698
D2E	0.000652	0.00071	0.000726	0.000666	0.000699	0.000715
D3E	0.000683	0.000677	0.000675	0.000676	0.000721	0.000718
E1A	0.000679	0.000698	0.000721	0.000731	0.000744	0.000704
E1E	0.00069	0.000688	0.000632	0.000689	0.000664	0.000689
E2E	0.000706	0.000692	0.000725	0.000725	0.000706	0.000733
E3E	0.000726	0.000681	0.000646	0.000705	0.000674	0.000749

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	0.00425	0.000708333	9.37467E-10		
A1E	6	0.00419	0.000698333	4.15467E-10		
A2E	6	0.004132	0.000688667	9.31467E-10		
A3E	6	0.004082	0.000680333	1.70507E-09		
B1A	6	0.004138	0.000689667	8.01467E-10		
B1E	6	0.004124	0.000687333	1.92267E-10		
B2E	6	0.004113	0.0006855	3.867E-10		
B3E	6	0.004297	0.000716167	1.02777E-09		
C1A	6	0.004234	0.000705667	6.05867E-10		
C1E	6	0.004318	0.000719667	7.41467E-10		
C2E	6	0.004171	0.000695167	7.24567E-10		
C3E	6	0.004065	0.0006775	6.423E-10		
D1A	6	0.004101	0.0006835	6.103E-10		
D1E	6	0.004161	0.0006935	1.0019E-09		
D2E	6	0.004168	0.000694667	8.58267E-10		
D3E	6	0.00415	0.000691667	4.73467E-10		
E1A	6	0.004277	0.000712833	5.62167E-10		
E1E	6	0.004052	0.000675333	5.51067E-10		
E2E	6	0.004287	0.0007145	2.427E-10		
E3E	6	0.004181	0.000696833	1.39897E-09		
			0.000695758			

ANOVA

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.99245E-08	19	1.04866E-09	1.416080882	0.136445671	1.691495727
Within groups	7.40535E-08	100	7.40535E-10			
Total	9.3978E-08	119				

within-sd	2.72128E-05	
effective n	5.00	
s_bb	7.85013E-06	
s_bb_min	4.57662E-06	
u_bb	7.85013E-06	0.007850127
u_bb(rel.)	1.128283551	

Cadmium:

	1	2	3	4	5	6
A1A	0.001116	0.001188	0.001166	0.001155	0.00111	0.001112
A1E	0.001082	0.001154	0.00113	0.001145	0.001131	0.001122
A2E	0.001163	0.001151	0.001112	0.001176	0.001148	0.001156
A3E	0.001046	0.001167	0.001152	0.001129	0.001123	0.001125
B1A	0.00107	0.001151	0.001138	0.001138	0.001125	0.001144
B1E	0.001155	0.001142	0.001175	0.001146	0.001107	0.001116
B2E	0.001188	0.001179	0.0012	0.001134	0.001136	0.001139
B3E	0.001126	0.001132	0.001129	0.001136	0.001132	0.001114
C1A	0.001143	0.00113	0.001191	0.001121	0.001137	0.001102
C1E	0.001041	0.001142	0.001108	0.001108	0.001112	0.001174
C2E	0.001187	0.001143	0.001134	0.001159	0.001144	0.001166
C3E	0.00113	0.001158	0.001162	0.001172	0.001149	0.001167
D1A	0.001058	0.00116	0.001202	0.001167	0.00113	0.001119
D1E	0.001064	0.001149	0.001183	0.001144	0.001141	0.001134
D2E	0.001066	0.001157	0.001158	0.001112	0.001089	0.001143
D3E	0.001065	0.001137	0.001139	0.001119	0.001136	0.001168
E1A	0.001137	0.001121	0.001134	0.001099	0.001108	0.001126
E1E	0.001046	0.001133	0.001175	0.001134	0.001101	0.00112
E2E	0.001066	0.001089	0.001147	0.001096	0.001121	0.001177
E3E	0.001151	0.00114	0.001122	0.001107	0.001141	0.001129

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	0.006847	0.001141167	1.09137E-09		
A1E	6	0.006764	0.001127333	6.25467E-10		
A2E	6	0.006906	0.001151	4.648E-10		
A3E	6	0.006742	0.001123667	1.74867E-09		
B1A	6	0.006766	0.001127667	8.71467E-10		
B1E	6	0.006841	0.001140167	6.30967E-10		
B2E	6	0.006976	0.001162667	8.79067E-10		
B3E	6	0.006769	0.001128167	5.93667E-11		
C1A	6	0.006824	0.001137333	8.96267E-10		
C1E	6	0.006685	0.001114167	1.95777E-09		
C2E	6	0.006933	0.0011555	3.731E-10		
C3E	6	0.006938	0.001156333	2.28267E-10		
D1A	6	0.006836	0.001139333	2.44707E-09		
D1E	6	0.006815	0.001135833	1.53097E-09		
D2E	6	0.006725	0.001120833	1.45577E-09		
D3E	6	0.006764	0.001127333	1.18267E-09		
E1A	6	0.006725	0.001120833	2.20567E-10		
E1E	6	0.006709	0.001118167	1.84137E-09		
E2E	6	0.006696	0.001116	1.6672E-09		
E3E	6	0.00679	0.001131667	2.47867E-10		
			0.001133758			
ANOVA						
Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	2.27578E-08	19	1.19778E-09	1.173142319	0.295527584	1.691495727
Within groups	1.021E-07	100	1.021E-09			
Total	1.24858E-07	119				
within-sd	3.19531E-05					
effective n	5.00					
s_bb	5.94607E-06					
s_bb_min	5.37385E-06					
u_bb	5.94607E-06	0.005946068				
u_bb(rel.)	0.524456348					

Cobalt:

	1	2	3	4	5	6
A1A	0.002223	0.002138	0.002174	0.002193	0.002305	0.002342
A1E	0.002473	0.002184	0.002157	0.002187	0.002252	0.002195
A2E	0.002144	0.002203	0.002291	0.002173	0.002244	0.002181
A3E	0.002461	0.002134	0.002035	0.002231	0.002239	0.002165
B1A	0.002451	0.00213	0.002169	0.002226	0.002296	0.002179
B1E	0.002097	0.002161	0.002054	0.002119	0.002271	0.002179
B2E	0.002087	0.002078	0.001945	0.002196	0.002157	0.002244
B3E	0.002199	0.002321	0.002284	0.002251	0.002182	0.002266
C1A	0.00214	0.002185	0.002029	0.002265	0.002198	0.002304
C1E	0.00248	0.002127	0.002255	0.002268	0.002232	0.002141
C2E	0.00208	0.002199	0.002132	0.002128	0.00212	0.002178
C3E	0.002234	0.002064	0.001971	0.002196	0.002211	0.002153
D1A	0.002407	0.002191	0.00191	0.002124	0.00227	0.002321
D1E	0.002468	0.00223	0.002055	0.002252	0.002245	0.002294
D2E	0.002481	0.002143	0.001968	0.002258	0.002211	0.002228
D3E	0.002402	0.002213	0.002109	0.002251	0.002279	0.00226
E1A	0.002129	0.002234	0.002269	0.002239	0.002345	0.002227
E1E	0.002525	0.00217	0.00213	0.002247	0.002276	0.002256
E2E	0.002583	0.002339	0.002073	0.002235	0.00231	0.002186
E3E	0.002221	0.002311	0.002282	0.002276	0.002216	0.002364

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	0.013375	0.002229167	6.23657E-09		
A1E	6	0.013448	0.002241333	1.38563E-08		
A2E	6	0.013236	0.002206	2.8472E-09		
A3E	6	0.013265	0.002210833	2.0541E-08		
B1A	6	0.013451	0.002241833	1.3739E-08		
B1E	6	0.012881	0.002146833	5.70577E-09		
B2E	6	0.012707	0.002117833	1.11942E-08		
B3E	6	0.013503	0.0022505	2.7355E-09		
C1A	6	0.013121	0.002186833	9.41417E-09		
C1E	6	0.013503	0.0022505	1.61163E-08		
C2E	6	0.012837	0.0021395	1.8263E-09		
C3E	6	0.012829	0.002138167	1.02998E-08		
D1A	6	0.013223	0.002203833	3.04518E-08		
D1E	6	0.013544	0.002257333	1.75183E-08		
D2E	6	0.013289	0.002214833	2.77966E-08		
D3E	6	0.013514	0.002252333	9.05267E-09		
E1A	6	0.013443	0.0022405	4.8783E-09		
E1E	6	0.013604	0.002267333	1.90687E-08		
E2E	6	0.013726	0.002287667	2.99095E-08		
E3E	6	0.01367	0.002278333	3.11947E-09		
			0.002218075			

ANOVA

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	2.79121E-07	19	1.46906E-08	1.146325618	0.319118513	1.691495727
Within groups	1.28154E-06	100	1.28154E-08			
Total	1.56066E-06	119				
within-sd	0.000113205					
effective n	5.00					
s_bb	1.9366E-05					
s_bb_min	1.90387E-05					
u_bb	1.9366E-05	0.019366026				
u_bb(rel.)	0.873100576					

Manganese:

	1	2	3	4	5	6
A1A	0.005335	0.005277	0.005218	0.005217	0.005153	0.005153
A1E	0.005372	0.005259	0.005212	0.005207	0.005259	0.005273
A2E	0.005354	0.00527	0.00523	0.005212	0.005259	0.005248
A3E	0.005419	0.005293	0.005353	0.005248	0.005207	0.005185
B1A	0.00549	0.005281	0.005246	0.005216	0.005287	0.005202
B1E	0.005413	0.005308	0.005254	0.005268	0.005219	0.005242
B2E	0.005386	0.005335	0.005358	0.005201	0.005192	0.005216
B3E	0.005358	0.005232	0.005164	0.005252	0.005235	0.005232
C1A	0.005313	0.005297	0.005357	0.005154	0.00521	0.005216
C1E	0.005385	0.005292	0.005238	0.005193	0.005277	0.005193
C2E	0.005325	0.005315	0.005233	0.005232	0.005223	0.00518
C3E	0.00531	0.005314	0.005378	0.005221	0.005203	0.005209
D1A	0.005374	0.005273	0.005392	0.005205	0.005186	0.005166
D1E	0.005379	0.005255	0.00532	0.005175	0.005187	0.005146
D2E	0.005371	0.005277	0.005332	0.00526	0.0052	0.005184
D3E	0.005431	0.005263	0.005217	0.005189	0.005161	0.005215
E1A	0.005382	0.005262	0.005171	0.005254	0.0052	0.005248
E1E	0.005436	0.005258	0.005263	0.005201	0.005287	0.005191
E2E	0.005355	0.005252	0.005394	0.005216	0.005221	0.005186
E3E	0.005309	0.005264	0.005195	0.005231	0.005196	0.005207

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	0.031353	0.0052255	5.0567E-09		
A1E	6	0.031582	0.005263667	3.54947E-09		
A2E	6	0.031573	0.005262167	2.45137E-09		
A3E	6	0.031705	0.005284167	8.01857E-09		
B1A	6	0.031722	0.005287	1.10384E-08		
B1E	6	0.031704	0.005284	4.8724E-09		
B2E	6	0.031688	0.005281333	7.68307E-09		
B3E	6	0.031473	0.0052455	3.9631E-09		
C1A	6	0.031547	0.005257833	5.84617E-09		
C1E	6	0.031578	0.005263	5.2692E-09		
C2E	6	0.031508	0.005251333	3.21627E-09		
C3E	6	0.031635	0.0052725	5.1547E-09		
D1A	6	0.031596	0.005266	9.542E-09		
D1E	6	0.031462	0.005243667	8.34707E-09		
D2E	6	0.031624	0.005270667	5.29747E-09		
D3E	6	0.031476	0.005246	9.358E-09		
E1A	6	0.031517	0.005252833	5.25617E-09		
E1E	6	0.031636	0.005272667	7.79947E-09		
E2E	6	0.031624	0.005270667	7.05907E-09		
E3E	6	0.031402	0.005233667	2.04547E-09		
			0.005261708			
ANOVA						
Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	3.34863E-08	19	1.76244E-09	0.291735904	0.998273045	1.691495727
Within groups	6.04121E-07	100	6.04121E-09			
Total	6.37607E-07	119				
within-sd	7.77252E-05					
effective n	5.00					
s_bb	0					
s_bb_min	1.30718E-05					
u_bb	1.30718E-05	0.013071767				
u_bb(rel.)	0.248431987					

Nickel:

	1	2	3	4	5	6
A1A	0.001158	0.001403	0.001283	0.001399	0.000999	0.000798
A1E	0.001228	0.001303	0.001063	0.001295	0.001466	0.00149
A2E	0.001275	0.001538	0.001088	0.001323	0.001433	0.001573
A3E	0.001275	0.001257	0.002066	0.001371	0.000912	0.001204
B1A	0.00143	0.001555	0.001414	0.001488	0.001713	0.001288
B1E	0.001331	0.00137	0.001619	0.001599	0.001402	0.001606
B2E	0.0014	0.001493	0.002322	0.001028	0.00139	0.001208
B3E	0.000943	0.00109	0.000766	0.001315	0.001467	0.001103
C1A	0.001328	0.001626	0.002159	0.000696	0.001366	0.001288
C1E	0.000995	0.001749	0.001164	0.001025	0.001531	0.001222
C2E	0.001343	0.001498	0.001351	0.001489	0.001454	0.001221
C3E	0.000888	0.001633	0.002223	0.001265	0.001274	0.00125
D1A	0.001434	0.001541	0.002457	0.001283	0.001043	0.000951
D1E	0.001213	0.00133	0.002041	0.001205	0.001068	0.000881
D2E	0.001362	0.001307	0.002266	0.001209	0.001355	0.001034
D3E	0.001375	0.001528	0.001363	0.000836	0.001188	0.001426
E1A	0.001142	0.00142	0.00099	0.00141	0.001242	0.001499
E1E	0.00133	0.001247	0.00146	0.001035	0.001489	0.001178
E2E	0.000958	0.001124	0.002124	0.001132	0.001431	0.000904
E3E	0.001089	0.001005	0.001181	0.001203	0.00132	0.000982

Sample	*Number*	*Sum*	*Mean*	*Variance*
A1A	6	0.00703992	0.00117332	5.74603E-08
A1E	6	0.007844966	0.001307494	2.4942E-08
A2E	6	0.008229585	0.001371598	3.28447E-08
A3E	6	0.008084784	0.001347464	1.48104E-07
B1A	6	0.008888216	0.001481369	2.07532E-08
B1E	6	0.00892767	0.001487945	1.78357E-08
B2E	6	0.00884183	0.001473638	2.00327E-07
B3E	6	0.006683648	0.001113941	6.32181E-08
C1A	6	0.008462966	0.001410494	2.28159E-07
C1E	6	0.007685693	0.001280949	8.91152E-08
C2E	6	0.008356239	0.001392706	1.15793E-08
C3E	6	0.00853308	0.00142218	2.09485E-07
D1A	6	0.008709199	0.001451533	2.93021E-07
D1E	6	0.007737903	0.001289651	1.59067E-07
D2E	6	0.008532602	0.0014221	1.85927E-07
D3E	6	0.007716244	0.001286041	6.08323E-08
E1A	6	0.00770329	0.001283882	3.77757E-08
E1E	6	0.007738511	0.001289752	2.99082E-08
E2E	6	0.007672557	0.001278759	2.05329E-07
E3E	6	0.006779489	0.001129915	1.66719E-08
			0.001334737	

ANOVA

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.41809E-06	19	7.46364E-08	0.713420496	0.797310864	1.691495727
Within groups	1.04618E-05	100	1.04618E-07			
Total	1.18799E-05	119				

within-sd	0.000323447	
effective n	5.00	
s_bb	0	
s bb min	5.4397E-05	
u bb	5.4397E-05	0.054397029
u bb(rel.)	4.075487941	

Phosphor:

	1	2	3	4	5	6
A1A	0.001127	0.001255	0.001072	0.001078	0.001147	0.001122
A1E	0.001116	0.001242	0.001137	0.001091	0.001163	0.001068
A2E	0.001187	0.001105	0.001089	0.001192	0.00112	0.001184
A3E	0.001118	0.001218	0.0013	0.001083	0.001131	0.001208
B1A	0.001195	0.001135	0.001155	0.001187	0.001199	0.001079
B1E	0.001188	0.001099	0.001161	0.001152	0.001274	0.001184
B2E	0.001154	0.001203	0.00125	0.001071	0.001179	0.001179
B3E	0.001101	0.001111	0.00107	0.001144	0.001187	0.001112
C1A	0.001163	0.001181	0.001143	0.001203	0.001184	0.001092
C1E	0.001105	0.001192	0.001141	0.00106	0.00121	0.001086
C2E	0.001223	0.00119	0.001169	0.0011	0.0012	0.001208
C3E	0.001129	0.001179	0.001288	0.001157	0.001194	0.001178
D1A	0.001185	0.001118	0.001265	0.001155	0.001101	0.001045
D1E	0.001189	0.001178	0.00121	0.001188	0.001105	0.001102
D2E	0.001142	0.001137	0.001217	0.001094	0.001234	0.001204
D3E	0.001087	0.001237	0.001167	0.001092	0.001108	0.001115
E1A	0.001167	0.001137	0.001241	0.00107	0.001203	0.001091
E1E	0.001106	0.001127	0.001266	0.001075	0.001181	0.00118
E2E	0.001069	0.001046	0.001149	0.001093	0.001153	0.001139
E3E	0.001176	0.001106	0.001103	0.001111	0.001098	0.001025

Sample	*Number*	*Sum*	*Mean*	*Variance*
A1A	6	0.006801	0.0011335	4.3963E-09
A1E	6	0.006817	0.001136167	3.80297E-09
A2E	6	0.006877	0.001146167	2.16937E-09
A3E	6	0.007058	0.001176333	6.44027E-09
B1A	6	0.00695	0.001158333	2.13387E-09
B1E	6	0.007058	0.001176333	3.30827E-09
B2E	6	0.007036	0.001172667	3.53307E-09
B3E	6	0.006725	0.001120833	1.61337E-09
C1A	6	0.006966	0.001161	1.5564E-09
C1E	6	0.006794	0.001132333	3.55867E-09
C2E	6	0.00709	0.001181667	1.92747E-09
C3E	6	0.007125	0.0011875	2.9315E-09
D1A	6	0.006869	0.001144833	5.75297E-09
D1E	6	0.006972	0.001162	2.1628E-09
D2E	6	0.007028	0.001171333	3.01987E-09
D3E	6	0.006806	0.001134333	3.34147E-09
E1A	6	0.006909	0.0011515	4.2831E-09
E1E	6	0.006935	0.001155833	4.64057E-09
E2E	6	0.006649	0.001108167	2.05137E-09
E3E	6	0.006619	0.001103167	2.30217E-09
			0.0011507	

ANOVA

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	6.58942E-08	19	3.46812E-09	1.068332093	0.394475013	1.691495727
Within groups	3.24629E-07	100	3.24629E-09			
Total	3.90523E-07	119				

within-sd	5.69762E-05	
effective n	5.00	
s_bb	6.66072E-06	
s bb min	9.58222E-06	
u bb	9.58222E-06	0.00958222
u bb(rel.)	0.832729674	

Antimony.

	1	2	3	4	5	6
A1A	0.042555	0.042222	0.041622	0.041343	0.040976	0.040486
A1E	0.042223	0.042083	0.04172	0.041552	0.041746	0.041606
A2E	0.042386	0.041926	0.04215	0.041781	0.041591	0.041457
A3E	0.042122	0.04233	0.043152	0.042046	0.040463	0.04112
B1A	0.042099	0.042092	0.041806	0.041706	0.04156	0.040369
B1E	0.042876	0.042311	0.042264	0.041505	0.041527	0.041868
B2E	0.042782	0.042522	0.043148	0.04148	0.041413	0.041522
B3E	0.041691	0.041396	0.041356	0.042062	0.041545	0.041003
C1A	0.042569	0.04232	0.043112	0.041317	0.041107	0.041562
C1E	0.041999	0.041667	0.0418	0.041922	0.041606	0.041114
C2E	0.042686	0.041889	0.042081	0.041718	0.041409	0.041252
C3E	0.042304	0.042113	0.043046	0.041765	0.041476	0.04102
D1A	0.042335	0.041893	0.043316	0.041558	0.041124	0.040814
D1E	0.041517	0.041526	0.042348	0.041545	0.040704	0.040771
D2E	0.042123	0.041786	0.043211	0.041783	0.041171	0.041243
D3E	0.041908	0.041762	0.041726	0.041323	0.041685	0.041538
E1A	0.042234	0.041879	0.041485	0.042074	0.041778	0.041639
E1E	0.04254	0.042264	0.042125	0.041468	0.041517	0.041235
E2E	0.041252	0.041098	0.042694	0.041266	0.04146	0.040748
E3E	0.041991	0.041808	0.04169	0.041673	0.041144	0.041639

Sample	*Number*	*Sum*	*Mean*	*Variance*		
A1A	6	0.249204	0.041534	5.93936E-07		
A1E	6	0.25093	0.041821667	7.29315E-08		
A2E	6	0.251291	0.041881833	1.20657E-07		
A3E	6	0.251233	0.041872167	8.98345E-07		
B1A	6	0.249632	0.041605333	4.12305E-07		
B1E	6	0.252351	0.0420585	2.79887E-07		
B2E	6	0.252867	0.0421445	5.84017E-07		
B3E	6	0.249053	0.041508833	1.26489E-07		
C1A	6	0.251987	0.041997833	6.23692E-07		
C1E	6	0.250108	0.041684667	1.00119E-07		
C2E	6	0.251035	0.041839167	2.64517E-07		
C3E	6	0.251724	0.041954	4.95361E-07		
D1A	6	0.25104	0.04184	8.14253E-07		
D1E	6	0.248411	0.041401833	3.65866E-07		
D2E	6	0.251317	0.041886167	5.51415E-07		
D3E	6	0.249942	0.041657	4.10576E-08		
E1A	6	0.251089	0.041848167	7.62766E-08		
E1E	6	0.251149	0.041858167	2.71552E-07		
E2E	6	0.248518	0.041419667	4.46377E-07		
E3E	6	0.249945	0.0416575	7.98387E-08		
			0.04177355			
ANOVA						
Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	4.88206E-06	19	2.56951E-07	0.711883956	0.798887291	1.691495727
Within groups	3.60945E-05	100	3.60945E-07			
Total	4.09765E-05	119				
within-sd	0.000600787					
effective n	5.00					
s_bb	0					
s_bb min	0.00010104					
u_bb	0.00010104	0.101039864				
u_bb(rel.)	0.241875216					

Annex 2: Calculation of uncertainty contribution of potential inhomogeneity (area)

Lead:

r_0	0.52133863	0.53244737						
r_middle	0.546197	0.55338	0.553921	0.552571				
r_out	0.549972	0.555667	0.542692	0.548033	0.546325	0.54558	0.550912	0.548672

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	2.45734E-05	1	2.45734E-05	1.691815824	0.222535716	4.964602744
Within groups	0.000145249	10	1.45249E-05			
Total	0.000169822	11				

within-sd	0.003811149
effective n	4.00
s_bb	0.001584971
s_bb_min	0.001274335
u_bb	0.001584971
u_bb(rel.)	0.290146899

Iron:

r_0	0.025839862	0.026250138						
r_in	0.025557	0.025771	0.025666	0.025474				
r_out	0.026155	0.026019	0.02618	0.02604	0.025999	0.025823	0.02585	0.025727

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	4.01933E-07	2	2.00967E-07	7.001926118	0.010930038	3.982297957
Within groups	3.15718E-07	11	2.87016E-08			
Total	7.17651E-07	13				

within-sd	0.000169416
effective n	4.00
s_bb	0.000207524
s_bb_min	5.53137E-05
u_bb	0.000207524
u_bb(rel.)	0.801802178

Tin:

r_in	0.034416	0.034503	0.034267	0.034262				
r_out	0.034513	0.034614	0.034843	0.034614	0.034722	0.034407	0.034874	0.034435

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.88328E-07	1	1.88328E-07	7.324937299	0.022067217	4.964602744
Within groups	2.57106E-07	10	2.57106E-08			
Total	4.45434E-07	11				

within-sd	0.000160345		
effective n	4.00		
s_bb	0.000201629		
s_bb_min	5.36146E-05		
u_bb	0.000201629	0.034443857	
u_bb(rel.)	0.585385581		

Aluminium:

r_0	0.246418382	0.249703618						
r_middle	0.246924	0.248313	0.24968	0.248629				
r_out	0.248794	0.247508	0.249062	0.248535	0.249475	0.248968	0.248406	0.248437

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	6.10956E-07	2	3.05478E-07	0.288010211	0.755237776	3.982297957
Within groups	1.16671E-05	11	1.06065E-06			
Total	1.22781E-05	13				

within-sd	0.001029878		
effective n	4.00		
s_bb	0		
s_bb_min	0.000336252		
u_bb	0.000336252	0.2484895	
u_bb(rel.)	0.135318502		

Arsenic:

r_0	0.057599658	0.058462342						
r_middle	0.05893	0.059233	0.059247	0.0587				
r_out	0.05921	0.058486	0.058581	0.059404	0.058884	0.059544	0.059208	0.058889

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	8.16667E-12	1	8.16667E-12	6.72752E-05	0.993617029	4.964602744
Within groups	1.21392E-06	10	1.21392E-07			
Total	1.21393E-06	11				

within-sd	0.000348413
effective n	4.00
s_bb	0
s_bb_min	0.000116499
u_bb	0.000116499
u_bb(rel.)	0.197844468

Silicon:

r_0	0.183135639	0.184332361						
r_in	0.186086	0.185552	0.185616	0.185241				
r_out	0.186983	0.186165	0.187096	0.185588	0.186474	0.185638	0.186278	0.185721

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.01105E-05	2	5.05524E-06	15.95688904	0.000560245	3.982297957
Within groups	3.48486E-06	11	3.16806E-07			
Total	1.35953E-05	13				

within-sd	0.000562855
effective n	4.00
s_bb	0.001088397
s_bb_min	0.000183771
u_bb	0.001088397
u_bb(rel.)	0.586080984

Bismuth:

r_0	0.000621635	0.000730365						
r_in	0.000673	0.000649	0.000702	0.000622				
r_out	0.000746	0.000704	0.000683	0.000649	0.00064	0.000758	0.000696	0.000658
Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*		
Between groups	2.49521E-09	2	1.24761E-09	0.606660169	0.56243735	3.982297957		
Within groups	2.26217E-08	11	2.05652E-09					
Total	2.51169E-08	13						
within-sd	4.53488E-05							
effective n	4.00							
s_bb	0							
s_bb min	1.48063E-05							
u_bb	1.48063E-05			0.000680857				
u_bb(rel.)	2.174650752							

Cadmium:

r_0	0.000995136	0.001082864						
r_middle	0.00112	0.001087	0.001094	0.00105				
r_out	0.001136	0.001126	0.001087	0.001089	0.001069	0.001111	0.001141	0.001078
Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*		
Between groups	6.9308E-09	2	3.4654E-09	3.26067282	0.077274954	3.982297957		
Within groups	1.16907E-08	11	1.06279E-09					
Total	1.86215E-08	13						
within-sd	3.26004E-05							
effective n	4.00							
s_bb	2.45082E-05							
s_bb min	1.06439E-05							
u_bb	2.45082E-05			0.001090429				
u_bb(rel.)	2.247578268							

Cobalt:

r_0	0.00212045	0.00227155						
r_middle	0.00218	0.002243	0.00227	0.002286				
r_out	0.002195	0.002143	0.002247	0.00217	0.002173	0.002167	0.002339	0.002239

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	4.4558E-09	2	2.2279E-09	0.528996525	0.603458081	3.982297957
Within groups	4.63272E-08	11	4.21156E-09			
Total	5.0783E-08	13				

within-sd	6.48966E-05
effective n	4.00
s_bb	0
s_bb_min	2.11885E-05
u_bb	2.11885E-05
u_bb(rel.)	0.955545351

Manganese:

r_0	0.005200535	0.005277465						
r_in	0.005273	0.005304	0.005248	0.005264				
r_out	0.005339	0.005331	0.005348	0.005307	0.005292	0.005287	0.005277	0.005252

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	7.80123E-09	2	3.90062E-09	3.463351125	0.068140849	3.982297957
Within groups	1.23888E-08	11	1.12625E-09			
Total	2.019E-08	13				

within-sd	3.35597E-05
effective n	4.00
s_bb	2.63361E-05
s_bb_min	1.09572E-05
u_bb	2.63361E-05
u_bb(rel.)	0.49825059

Nickel:

r_0	0.001377822	0.001980178						
r_in	0.001705	0.002126	0.001672	0.001867				
r_out	0.001872	0.001919	0.001746	0.001862	0.001649	0.001687	0.001686	0.001958

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	3.59443E-08	2	1.79722E-08	0.482245238	0.62985651	3.982297957
Within groups	4.09945E-07	11	3.72677E-08			
Total	4.45889E-07	13				

within-sd	0.000193048							
effective n	4.00							
s_bb	0							
s_bb_min	6.30298E-05							
u_bb	6.30298E-05			0.001793357				
u bb(rel.)	3.514623641							

Phosphor:

r 0	0.001108642	0.001291358						
r_middle	0.001157	0.001199	0.001254	0.001127				
r_out	0.001301	0.00119	0.001197	0.001037	0.001277	0.001135	0.001227	0.001212

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	5.23607E-10	2	2.61804E-10	0.039112644	0.961775497	3.982297957
Within groups	7.36294E-08	11	6.69358E-09			
Total	7.4153E-08	13				

within-sd	8.18143E-05							
effective n	4.00							
s_bb	0							
s bb min	2.67121E-05							
u bb	2.67121E-05			0.001193786				
u bb(rel.)	2.237598444							

Antimony:

r_0	0.040913057	0.041676943						
r_middle	0.041404	0.041783	0.041643	0.041411				
r_out	0.042136	0.042759	0.042634	0.04185	0.042008	0.041487	0.041851	0.041436

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.12452E-06	2	5.6226E-07	3.070570062	0.087184923	3.982297957
Within groups	2.01424E-06	11	1.83113E-07			
Total	3.13876E-06	13				

within-sd	0.000427917
effective n	4.00
s_bb	0.000307875
s_bb_min	0.000139714
u_bb	0.000307875
u_bb(rel.)	0.736804355