in cooperation with the WG 'Copper'
of the Committee of Chemists of GDMB

CERTIFICATE OF ANALYSIS

ERM®-EB386

Pure copper

Certified Values		
	Certified value 1)	Uncertainty 2)
Element	Mass fraction in mg/kg	
Ag	47.4	± 1.2
Al	36.5	± 2.5
As	24.2	± 1.0
Bi	9.6	± 0.5
Cd	7.8	± 0.4
Co	5.20	± 0.14
Cr	12.4	± 0.7
Fe	64.7	± 1.8
Mg	36.1	± 1.2
Mn	13.3	± 0.2
Ni	25.0	± 1.0
P	7.2	± 0.7
Pb	23.4	± 1.2
S	21.9	± 2.1
Sb	31.2	± 1.1
Se	11.6	± 0.3
Sn	28.3	± 0.8
Te	38.3	± 0.9
Ti	33.1	± 1.3
Zn	49.5	± 1.6

1) Unweighted mean value of the means of accepted sets of data (at least 4 but usually 6), each set being obtained in a different laboratory and/or a different method of measurement. The values are traceable to the SI (Système International d'Unités) via calibration using sufficiently pure substances of known stoichiometry.

2) Estimated expanded uncertainty *U* with a coverage factor of about k=2, corresponding to a level of confidence of 95 %, as defined in the Guide to the expression of uncertainty in measurement, ISO, 1993.

This certificate is valid until 09/2053; this validity may be extended as further evidence of stability becomes available.

The minimum sample size for wet chemical analysis is 0.5 g.

NOTE

European Reference Material ERM®-EB386 was originally certified as BAM-M386. It was produced and certified under the responsibility of Bundesanstalt für Materialforschung und –prüfung (BAM) in cooperation with the Committee of Chemists of the GDMB, Gesellschaft für Bergbau, Metallurgie, Rohstoff- und Umwelttechnik according to the principles laid down in the technical guidelines of the European Reference Materials® co-operation agreement between BAM-LGC-IRMM. Information on these guidelines is available on the Internet (http://www.erm-crm.org).

Accepted as an ERM®, Berlin, 2004-04-14.

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Indicative Values[3]		
	Indicative value [4]	Uncertainty [5]
Element	Mass fraction in mg/kg	
Si	14.3	± 4.3
Zr	8.9	± 1.7

[3] Values were not certified, but given as indicative values, when the number of accepted data sets was considered to be too low, when the spread from the round robin certification was considerably larger than the state of the practice or when only 'lower as' values were reported from the round robin certification.

[4] Unweighted mean value of the means of accepted sets of data, each set being obtained in a different laboratory and/or a different method of measurement. The values are traceable to the SI (Système International d'Unités) via calibration using sufficiently pure substances of known stoichiometry.

[5] Estimated expanded uncertainty *U* with a coverage factor of about *k*=2, corresponding to a level of confidence of 95 %, as defined in the Guide to the expression of uncertainty in measurement, ISO, 1993.

DESCRIPTION OF THE SAMPLE

The Reference Material is available in the form of discs (40 mm diameter and 30 mm height). It is intended for establishing and checking the calibration of optical emission and X-ray spectrometers for the analysis of samples of similar materials

MEANS OF ACCEPTED DATA SETS (FOR ONE METHOD AT ONE LABORATORY, RESPECTIVELY)

Mass Fraction in mg/kg

Line no.	Ag	Al	As	Bi	Cd	Co	Cr	Fe	Mg	Mn	Ni	P	Pb	S	Sb	Se	Sn	Te	Ti	Zn
1	41.9	30.5	-	8.7	7.0	4.8	9.9	60.9	33.2	-	23.5	6.4	19.0	18.5	28.7	11.2	27.2	36.5	30.5	45.5
2	44.8	31.3	22.4	9.1	7.3	5.0	11.2	61.2	33.4	-	23.7	6.7	21.5	19.6	29.2	11.5	27.2	37.3	31.1	45.6
3	46.5	35.4	22.6	9.3	7.3	5.1	11.5	62.0	34.2	12.8	23.7	7.1	21.6	21.1	29.6	11.5	27.4	37.9	32.9	47.0
4	46.5	35.5	23.4	9.6	7.4	5.1	12.0	62.9	35.9	12.9	23.8	7.4	23.3	21.3	30.0	11.6	27.5	38.0	33.4	47.8
5	46.7	36.1	23.5	9.7	7.6	5.2	12.5	62.9	35.9	13.1	24.5	7.6	23.5	21.3	30.6	11.7	27.7	38.1	33.5	48.6
6	46.7	36.7	23.5	9.7	7.6	5.2	12.5	63.5	36.7	13.2	24.9	8.1	23.6	22.8	31.1	11.9	28.0	38.2	34.1	48.9
7	47.2	36.7	23.7	9.8	7.8	5.3	12.6	65.2	37.3	13.2	26.0		23.7	23.4	31.3	12.0	28.4	39.4	34.1	49.0
8	47.8	37.0	23.8	9.9	7.8	5.3	12.6	65.7	37.3	13.3	26.1		24.1	26.7	31.4		29.4	40.0	35.0	50.1
9	47.9	38.0	23.9	10.6	8.0	5.3	13.0	65.8	37.6	13.3	26.4		24.2		31.5		29.8	40.2		50.6
10	48.2	40.0	24.0		8.7	5.4	13.1	66.1	37.8	13.5	27.3		24.5		31.9		29.9			51.1
11	49.0	43.9	24.2		9.0	5.5	13.1	66.8	38.0	13.6	-		24.8		32.3					52.1
12	49.0		24.6				13.3	67.2		13.6			25.3		34.1					53.0
13	49.5		24.6				13.5	71.1					25.6		34.4					53.5
14	49.5		25.9																	-
15	50.0		29.0																	
M :	47.41	36.45	24.21	9.60	7.76	5.20	12.37	64.71	36.12	13.25	24.99	7.22	23.43	21.85	31.24	11.63	28.25	38.29	33.08	49.44
s_M :	2.10	3.69	1.63	0.55	0.60	0.20	1.0	2.85	1.76	0.28	1.35	0.64	1.79	2.49	1.71	0.27	1.09	1.19	1.55	2.59
$\bar{s}_i$:	0.6	0.8	0.6	0.4	0.2	0.2	0.3	1.0	0.5	0.3	0.6	0.4	0.5	0.8	0.5	0.6	0.6	1.0	0.8	1.1

The laboratory mean values have been examined statistically to eliminate outlying values. Where a " - " appears in the table it indicates that an outlying value has been omitted. A data set consists of at least 4 but usually 6 single values of one laboratory. " < "-values have not been considered in statistical evaluation.

M : mean of means of data sets

s_M : standard deviation of means of data sets

$\bar{s}_i$: mean of standard deviations of data sets under repeatability conditions

numbers in *italics* are indicative values

Mass fraction in mg/kg (indicative values)

Line No.	Si	Zr
1	*8.3*	*5.6*
2	*9.4*	*6.7*
3	*15.8*	*7.7*
4	*16.6*	*8.0*
5	*17.1*	*8.3*
6	*18.4*	*8.6*
7		*9.4*
8		*10.3*
9		*12.4*
10		*12.8*

ANALYTICAL METHOD USED FOR CERTIFICATION

Element	Line no.	Method
Ag	1, 2, 3, 5, 7, 8, 11	Atomic emission spectrometry with inductively coupled plasma
	4, 6, 10	Flame Atomic Absorption Spectrometry
	9	Electrothermal Atomic Absorption Spectrometry
	12**, 14*	Neutron Activation Analysis
	13	Activation Analysis with High-Energy Photons
	15	Mass spectrometry with inductively coupled plasma
Al	1, 4, 6, 7, 8, 9, 11	Atomic emission spectrometry with inductively coupled plasma
	2	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	3	Electrothermal Atomic Absorption Spectrometry
	5	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	10	Mass spectrometry with inductively coupled plasma
As	1	Mass spectrometry with inductively coupled plasma
	2, 15	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	3, 4, 6, 10, 13, 14	Atomic emission spectrometry with inductively coupled plasma
	5, 12	Electrothermal Atomic Absorption Spectrometry
	7	Flame Atomic Absorption Spectrometry
	8*	Neutron Activation Analysis
	9	Activation Analysis with High-Energy Photons
	11	Spectrophotometry
Bi	1, 3, 7	Electrothermal Atomic Absorption Spectrometry
	2, 5	Atomic emission spectrometry with inductively coupled plasma
	4, 9	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	6	Flame Atomic Absorption Spectrometry
	8	Mass spectrometry with inductively coupled plasma

Cd	1, 2, 6, 7, 8, 10	Atomic emission spectrometry with inductively coupled plasma
	3	Flame Atomic Absorption Spectrometry
	4, 9	Electrothermal Atomic Absorption Spectrometry
	5	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	11	Mass spectrometry with inductively coupled plasma
Co	1	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	2, 3, 4, 7	Atomic emission spectrometry with inductively coupled plasma
	5	Mass spectrometry with inductively coupled plasma
	6*, 8**	Neutron Activation Analysis
	9, 10, 11	Electrothermal Atomic Absorption Spectrometry
Cr	1	Activation Analysis with High-Energy Photons
	2	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	3	Mass spectrometry with inductively coupled plasma
	4, 6, 7, 9, 11, 12	Atomic emission spectrometry with inductively coupled plasma
	5	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	8**	Neutron Activation Analysis
	10	Electrothermal Atomic Absorption Spectrometry
Fe	1, 2, 5, 6, 7, 8, 13	Atomic emission spectrometry with inductively coupled plasma
	3	Mass spectrometry with inductively coupled plasma
	4	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	9	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	10, 11	Flame Atomic Absorption Spectrometry
	12	Spectrophotometry
Mg	1, 4, 5, 6, 8, 9, 10, 11	Atomic emission spectrometry with inductively coupled plasma
	2	Flame Atomic Absorption Spectrometry
	3	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	7	Mass spectrometry with inductively coupled plasma
Mn	1, 4, 7, 8, 9, 10, 11, 12	Atomic emission spectrometry with inductively coupled plasma
	2	Activation Analysis with High-Energy Photons
	3	Mass spectrometry with inductively coupled plasma
	5	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	6	Electrothermal Atomic Absorption Spectrometry
Ni	1	Mass spectrometry with inductively coupled plasma
	2, 4, 5, 9, 10, 11	Atomic emission spectrometry with inductively coupled plasma
	3	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	6	Activation Analysis with High-Energy Photons
	7	Spectrophotometry
	8	Electrothermal Atomic Absorption Spectrometry

P	1, 2, 4, 5	Atomic emission spectrometry with inductively coupled plasma
	3, 6	Spectrophotometry
Pb	1, 10	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	2	Activation Analysis with High-Energy Photons
	3, 7, 11	Electrothermal Atomic Absorption Spectrometry
	4	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	5	Flame Atomic Absorption Spectrometry
	6, 8, 12, 13	Atomic emission spectrometry with inductively coupled plasma
	9	Mass spectrometry with inductively coupled plasma
S	1, 2	Atomic emission spectrometry with inductively coupled plasma
	3, 6	Titration
	4, 5	Spectrophotometry
	7, 8	Carrier gas hot extraction with IR-detection (gas calibration)
Sb	1	Mass spectrometry with inductively coupled plasma
	2, 7	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	3, 4, 8, 11, 12	Atomic emission spectrometry with inductively coupled plasma
	5*, 10**	Neutron Activation Analysis
	6	Activation Analysis with High-Energy Photons
	9	Spectrophotometry
	13	Electrothermal Atomic Absorption Spectrometry
Se	1	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	2, 4, 5	Atomic emission spectrometry with inductively coupled plasma
	3**	Neutron Activation Analysis
	6, 7	Electrothermal Atomic Absorption Spectrometry
Si	1, 2, 3, 4, 6	Atomic emission spectrometry with inductively coupled plasma
	5	Electrothermal Atomic Absorption Spectrometry
Sn	1, 2, 3, 4, 8	Atomic emission spectrometry with inductively coupled plasma
	5, 9	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	6	Mass spectrometry with inductively coupled plasma
	7	Activation Analysis with High-Energy Photons
	8, 10	Electrothermal Atomic Absorption Spectrometry
Te	1, 4, 7	Atomic emission spectrometry with inductively coupled plasma
	2, 6	Electrothermal Atomic Absorption Spectrometry
	3	Activation Analysis with High-Energy Photons
	5, 9	Atomic emission spectrometry with inductively coupled plasma after Lanthanum precipitation
	8	Mass spectrometry with inductively coupled plasma
Ti	1, 4, 5, 6, 7, 8	Atomic emission spectrometry with inductively coupled plasma
	3	Electrothermal Atomic Absorption Spectrometry

Zn	1**, 2*	Neutron Activation Analysis
	3, 11	Flame Atomic Absorption Spectrometry
	4	Activation Analysis with High-Energy Photons
	5	Mass spectrometry with inductively coupled plasma
	6, 7, 9, 10, 12, 13, 14	Atomic emission spectrometry with inductively coupled plasma
	8	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
Zr	1	Atomic emission spectrometry with inductively coupled plasma after electrolytic Cu separation
	2	Mass spectrometry with inductively coupled plasma
	3, 4, 5, 6, 7, 8, 10	Atomic emission spectrometry with inductively coupled plasma
	9	Activation Analysis with High-Energy Photons

* after dissolution of the sample
** solid sample

PARTICIPANTS

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Laboratory I.11 (Metal Analysis)
Laboratory I.43 (Activation Analysis, Gas Analysis)
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INSTRUCTIONS FOR USE

Before use, the surface of the material must be cleaned by turning on a lathe.

STORAGE

The material should be stored at ambient conditions in a dry and clean environment.

TECHNICAL REPORT

A detailed technical report (in German) describing the analysis procedures and the treatment of the analytical data used to certify ERM®- EB386 is available on request.

Supply of Reference Materials by Bundesanstalt für Materialforschung und –prüfung:

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