BAM Bundesanstalt für Materialforschung und -prüfung

in co-operation with the Committee of Chemists of the GDMB
Gesellschaft der Metallurgen und Bergleute e.V.

Certified Reference Material

BAM-M384a

Pure Copper

Certified Values

Element	Mass fraction [1] in mg/kg	Uncertainty [2] in mg/kg
Ag	10.7	0.4
As	5.4	0.8
Bi	6.16	0.25
Cd	4.1	0.2
Co	3.64	0.16
Fe	2.7	0.5
Mn	0.22	0.03
Ni	6.1	0.5
Pb	11.7	1.1
Sb	5.4	0.5
Se	5.8	0.6
Sn	2.6	0.5
Te	9.3	0.5
Zn	5.3	0.5

[1] Unweighted mean value of the means of accepted sets of data (consisting of at least 3 but usually 6 single results), each set being obtained by a different laboratory and/or a different method of measurement. The values are traceable to the SI (Système International d'Unités) via calibration using pure metals or substances of known stoichiometry.

[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).

Sample description

The Reference Material is available in the form of discs (38 mm diameter and 30 mm height).

Indicative values

Element	Mass fraction [1] in mg/kg	Uncertainty [2] in mg/kg
Al	< 1.5	
Cr	< 0.2	
Mg	< 0.2	
P	< 1.5	
S	4.6	1.4
Si	< 2.5	
Ti	< 1	
Zr	0.1	0.07

[1] Values were not certified, but given as indicative values, when the number of accepted data sets was considered to be too low (< 5) or when the uncertainty from the inter-laboratory certification was considerably larger than the expected range. The values are traceable to the SI (Système International d'Unités) via calibration using pure metals or substances of known stoichiometry.

[2] Estimated expanded uncertainty *U* with a coverage factor of $k = 2$, as defined in the Guide to the expression of uncertainty in measurement, (GUM, ISO/IEC Guide 98-3:2008).

Informative Value

One laboratory determined oxygen and found 0.26 % mass fraction.

Recommended Use

The CRM is intended for establishing or checking the calibration of optical emission and X-ray spectrometers for the analysis of samples of similar matrix composition. The minimum sample size for wet chemical analysis is 0.5 g.

Participating Laboratories

Allgemeine Gold- und Silberscheideanstalt, Pforzheim, Germany
Aurubis AG, Hamburg, Germany
BAM Bundesanstalt für Materialforschung und -prüfung, Berlin, Germany
Codelco, Chuquicamata, Chile
Diehl Metall Stiftung & Co KG, Röthenbach, Germany
Institut Glörfeld, Willich, Germany
Johannes Gutenberg-Universität Mainz, Institut für Kernchemie, Mainz, Germany
Montanwerke Brixlegg, Brixlegg, Austria
Outokumpu VDM, Werdohl, Germany
Umicore Precious Metals., Hobocken, Belgium
Wieland-Werke AG, Vöhringen, Germany

Means of Accepted Data Sets

Mass fraction in mg/kg

Certified values | Indicative values

Line no.	Ag	As	Bi	Cd	Co	Fe	Mn	Ni	Pb	Sb	Se	Sn	Te	Zn		*Al*	*Cr*	*Mg*	*P*	*S*	*Si*	*Ti*	*Zr*
1	9.45	4.40	---	3.92	3.18	1.99	0.20	---	8.63	---	---	1.80	8.10	---		*0.03*	*0.015*	*0.03*	*0.06*	*< 1*	*0.10*	*0.05*	*0.02*
2	10.17	4.63	5.65	3.94	3.42	2.50	0.21	5.17	10.34	5.00	4.81	2.35	8.40	---		*0.32*	*0.018*	*0.03*	*0.13*	*3.34*	*< 1*	*0.06*	*0.03*
3	10.32	4.79	6.00	4.00	3.50	2.67	0.21	5.50	10.75	5.08	5.41	2.50	8.83	4.98		*< 1*	*0.022*	*0.08*	*0.21*	*4.20*	*1.83*	*0.08*	*< 0.05*
4	10.48	5.00	6.09	4.00	3.53	2.74	0.23	5.90	11.49	5.19	5.50	2.63	9.00	5.00		*< 1*	*0.026*	*0.15*	*< 1*	*4.80*		*---*	*0.15*
5	10.58	5.28	6.15	4.04	3.59	2.75	0.23	6.23	11.58	5.24	5.52	2.65	9.50	5.08		*1.30*	*0.193*	*< 1*	*< 1*			*< 1*	*0.15*
6	10.68	5.67	6.18	4.05	3.69	2.78	---	6.26	11.70	5.25	5.70	2.77	9.67	5.17			*< 1*	*< 1*	*1.37*			*< 1*	*0.17*
7	10.90	5.87	6.32	4.06	3.69	3.03	< 1	6.27	12.43	5.29	5.91	2.83	9.73	5.28			*< 1*	*< 1*	*1.52*			*< 1*	*< 1*
8	11.00	5.90	6.33	4.11	3.69	3.14	< 1	6.28	12.97	5.42	6.00	2.85	10.00	5.28			*< 1*	*< 1*					*< 1*
9	11.00	5.92	6.33	4.22	3.82	---	< 1	6.47	13.32	5.47	6.28	3.04	10.17	5.47			*< 1*						*< 1*
10	11.05	6.70	6.45	4.30	3.95		< 1	6.48	13.33	5.53	7.12		10.17	5.49									
11	11.07			---	4.00			6.75		5.73				6.15									
12	11.42				---					5.85													
13	---																						
M	10.68	5.42	6.16	4.06	3.64	2.70	0.22	6.13	11.63	5.37	5.80	2.60	9.36	5.32		*< 1.5*	*< 0.2*	*< 0.2*	*< 1.5*	*4.11*	*< 2*	*< 1*	*0.10*
s_M	0.53	0.72	0.24	0.12	0.24	0.36	0.10	0.46	1.48	0.27	0.65	0.37	0.74	0.36						*0.74*			*0.08*
$\bar{s}_i$	0.26	0.28	0.51	0.12	0.09	0.47	0.04	0.48	0.58	0.48	0.31	0.32	0.63	0.26						*0.35*			*0.07*

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 (Grubbs 95 %). A data set consists of at least 3 but usually 6 single values of one laboratory.

M : mean of laboratory means

s_M : standard deviation of laboratory means

$\bar{s}_i$: averaged repeatability standard deviation (square root of the mean of laboratory variances)

Note: "< - values" were not included into the calculation of M and s_M

Analytical Method used for Certification

Element	Line no.	Method
Ag	1, 5	GD-MS
	2, 6, 7, 8, 9, 10, 12	ICP-OES
	3, 11	INAA
	4	ICP-MS
As	1, 2	GD-MS
	3	ICP-MS
	4, 5, 7, 8, 9, 10	ICP-OES
	6	ET AAS
Bi	2	ICP-MS
	3, 6, 7, 10	ICP-OES
	4, 9	ET AAS
	5, 8	GD-MS
Cd	1, 2, 3, 4, 5, 6, 7, 9	ICP-OES
	8	GD-MS
	10	ICP-MS
Co	1, 2, 3, 4, 5, 8, 9, 11	ICP-OES
	7	ICP-MS
	6, 10	GD-MS
Fe	1, 2, 3, 4, 5, 6	ICP-OES
	7	ICP-MS
	8	GD-MS
Mn	1	GD-MS
	2, 3, 7, 8, 9, 10	ICP-OES
	4	ET AAS
	5	ICP-MS
Ni	2, 3, 4, 5, 6, 9, 11	ICP-OES
	8	ICP-MS
	7	GD-MS
	10	ET AAS
Pb	1, 3, 5, 6, 7, 9	ICP-OES
	2, 8	GD-MS
	4	ICP-MS
	10	ET AAS
Sb	2, 3, 5, 8, 11	ICP-OES
	4, 7	INAA
	6	ICP-MS
	9, 12	GD-MS
	10	ET AAS

Element	Line no.	Method
Se	2, 7	GD-MS
	3, 6	ET AAS
	4, 8, 9, 10	ICP-OES
	5	INAA
Sn	1, 8	GD-MS
	2, 4, 5, 7, 9	ICP-OES
	3	ET AAS
	6	ICP-MS
Te	1, 9	GD-MS
	2	INAA
	3, 4, 5, 6, 10	ICP-OES
	7	ICP-MS
	8	ET AAS
Zn	3, 4, 7, 8	ICP-OES
	5, 10	GD-MS
	6	FAAS
	9	ICP-MS
	11	INAA
Al	*1*	*GD-MS*
	2, 3, 4, 5	*ICP-OES*
Cr	*1, 4*	*GD-MS*
	2, 5, 6, 7, 8, 9	*ICP-OES*
	3	*ICP-MS*
Mg	*1, 2*	*GD-MS*
	3	*ICP-MS*
	4, 5, 6, 7, 8	*ICP-OES*
P	*1, 2*	*GD-MS*
	3	*ETV-ICP-OES*
	4, 5	*ICP-OES*
	6, 7	*Spectrophotometry*
S	*1, 3*	*ICP-OES*
	2	*GD-MS*
	4	*Combustion/iodometric titration*
Si	*1*	*GD-MS*
	2, 3	*ICP-OES*
Ti	*1, 5, 6, 7*	*ICP-OES*
	2	*GD-MS*
	3	*ICP-MS*
Zr	*1, 5, 7, 8, 9*	*ICP-OES*
	2	*ICP-MS*
	3, 6	*GD-MS*
	4	*INAA*

Abbreviations: ET AAS – Electrothermal atomic absorption spectrometry
ETV-ICP-OES – Inductively coupled plasma - optical emission spectrometry plasma after electrothermal vaporisation
FAAS – Flame atomic absorption spectrometry
GD-MS – Glow discharge mass spectrometry
ICP-MS – Mass spectrometry with inductively coupled plasma
ICP-OES – Inductively coupled plasma - optical emission spectrometry
INAA – Instrumental neutron activation analysis

Instructions for Use

Before use, the surface of the material must be prepared by milling or turning on a lathe. For wet chemical analysis chips have to be prepared by turning or milling of the sample surface.

Transport and Storage

The material should be stored in a dry and clean environment at room temperature (approx. 20 °C). Transport under normal ambient conditions.

Technical Report

A detailed technical report describing the analysis procedures and the treatment of the analytical data used to certify BAM-M384a is available on request or can be downloaded from BAM website (www.bam.de/en/fachthemen/referenzmaterialien/index.htm).

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