MBH ANALYTICAL LTD

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CERTIFICATE OF ANALYSIS

32X ALB2 (batch L)

Certified Reference Material Information

Type: ALUMINIUM BRONZE (CHILL CAST)

Form and Size: Disc ~40mm diameter

Manufactured by: Polycast Ltd

Certified and Supplied by: MBH Analytical Ltd

Assigned Values

Percentage element by weight

Element	Sn	Pb	Zn	Fe	Ni	Al	Si	As
Value [1]	**0.0806**	**0.0685**	**0.671**	**4.628**	**4.515**	**10.48**	**0.198**	**0.0062**
Uncertainty [2]	0.0011	0.0013	0.003	0.017	0.018	0.03	0.003	0.0004

Element	P	Mn	Co	Cr	Nb	Mg	Ag	Cu
Value [1]	**0.031**	**0.401**	**0.198**	**0.052**	**0.070**	**0.0088**	**0.018**	**78.50**
Uncertainty [2]	0.003	0.004	0.002	0.002	0.001	0.0006	0.001	0.08

Definitions

1 The certified values are the present best estimates of the true content for each element. Each value is a panel consensus, based on the averaged results of an interlaboratory testing programme, detailed on page 3.

2 The uncertainty values are generated from the 95% confidence interval derived from the wet analysis results, in combination with a statistical assessment of the homogeneity data, as described on page 2.

Certified by:

on 20th June 2016

MBH ANALYTICAL LIMITED _____

L Maxim

Method of Preparation

This reference material was produced from commercial-purity metals, binaries and master alloys. The discs are the product of one melt poured into a sequence of multiple chill moulds with feeding systems designed to ensure sound discs. Approximately 2mm has been removed from the cast faces of the discs to minimise surface effects.

Sampling

Milled samples for chemical analysis were taken from several positions within the batch. In addition, at least 15% of all discs were selected for homogeneity checking.

Homogeneity

Samples representative of the batch were checked for uniformity using an optical emission spectrometer. Multiple measurements were taken from each surface under test.

Using the meaned data from each surface, standard deviation values were derived for each element as an indicator of any non-homogeneity (as determined for the specific sample size taken by the spectrometer).

Chemical Analysis

Analysis was carried out on millings taken from samples representative of the product. It was performed by a panel of laboratories mostly operating within the terms of EN ISO/IEC 17025 - 2005, using documented standard reference methods and validated by appropriate reference materials.

The individual values listed overpage are the average of each analyst's results.

Estimation of Uncertainties

Each element certified has been analysed by several laboratories, and 95% half-width confidence intervals ($C_{(95\%)}$) for the resultant mean values have been derived by the method shown on page 3.

As a separate exercise, the degree of non-homogeneity of the batch for each element has been quantified by a programme of non-destructive application testing, discussed above.

The final certified uncertainty for each element has been derived by combining these two factors, using the square-root of the summed squares.

Traceability

Much of the analytical work performed to assess this material has been carried out by laboratories with proven competence, as indicated by their accreditation to ISO 17025. It is an implicit requirement for this accreditation that analytical work should be performed with due traceability, via an unbroken chain of comparisons, each with stated uncertainty, to primary standards such as the mole, or to nationally- or internationally-recognised reference materials. In addition, some of the results derived as part of this testing programme have traceability to NIST standards, as part of the analytical calibration or process control.

Usage

Intended use: With optical emission and X-ray fluorescence spectrometers.

Recommended method of use: Copper alloys are generally prepared by machining on a mill or a lathe. However, users are recommended to follow the calibration and sample preparation procedures specified by the relevant instrument manufacturer.

Preparation should be the same for reference materials and the samples for test.

For optical emission spectroscopy, a minimum of five consistent replicate analyses is recommended to provide the necessary sample size. Users are advised to check against possible bias between reference materials and production samples due to differences in metallurgical history, and be aware of possible inter-element effects.

Analytical Data

Percentage element by weight

Sample	Sn	Pb	Zn	Fe	Ni	Al	Si	As
1	0.0798	0.0666	0.6650	4.596	4.472	10.433	0.1940	0.0050
2	0.0801	0.0667	0.6660	4.601	4.479	10.440	0.1940	0.0051
3	0.0802	0.0668	0.6674	4.602	4.486	10.467	0.1950	0.0055
4	0.0802	0.0675	0.6708	4.616	4.488	10.478	0.1975	0.0058
5	0.0803	0.0675	0.6712	4.617	4.507	10.479	0.1997	0.0058
6	0.0805	0.0676	0.6720	4.623	4.512	10.480	0.2000	0.0059
7	0.0807	0.0681	0.6720	4.629	4.514	10.481	0.2006	0.0062
8	0.0810	0.0691	0.6725	4.635	4.517	10.492	0.2010	0.0062
9	0.0810	0.0691	0.6730	4.635	4.519	10.493	0.2011	0.0065
10	0.0817	0.0699	0.6740	4.644	4.520	10.499		0.0067
11		0.0699	0.6754	4.650	4.542	10.512		0.0067
12		0.0701	0.6764	4.651	4.544	10.520		0.0070
13		0.0710		4.660	4.550			0.0073
14					4.553			0.0075
Mean	**0.0806**	**0.0685**	**0.6713**	**4.628**	**4.515**	**10.481**	**0.1981**	**0.0062**
Std Dev	0.0006	0.0015	0.0035	0.021	0.026	0.026	0.0030	0.0008
$C_{(95\%)}$	0.0004	0.0009	0.0023	0.012	0.015	0.016	0.0023	0.0004

Sample	P	Mn	Co	Cr	Nb	Mg	Ag	Cu
1	0.0258	0.3968	0.1940	0.0495	0.0670	0.0078	0.0155	78.34
2	0.0270	0.3970	0.1942	0.0497	0.0680	0.0080	0.0157	78.40
3	0.0283	0.3976	0.1950	0.0501	0.0681	0.0080	0.0160	78.46
4	0.0306	0.3980	0.1960	0.0503	0.0692	0.0081	0.0165	78.48
5	0.0310	0.3990	0.1970	0.0503	0.0702	0.0081	0.0166	78.50
6	0.0323	0.3996	0.1979	0.0506	0.0704	0.0083	0.0173	78.52
7	0.0324	0.4010	0.1985	0.0513	0.0712	0.0084	0.0180	78.53
8	0.0366	0.4020	0.1989	0.0520	0.0713	0.0085	0.0184	78.57
9	0.0385	0.4024	0.1993	0.0555	0.0722	0.0089	0.0185	78.58
10		0.4030	0.1995	0.0559		0.0097	0.0190	78.61
11		0.4050	0.2000	0.0563		0.0098	0.0191	
12		0.4060	0.2003	0.0571		0.0098	0.0201	
13		0.4063				0.0099	0.0207	
14						0.0100	0.0211	
Mean	**0.0314**	**0.4011**	**0.1976**	**0.0524**	**0.0697**	**0.0088**	**0.0180**	**78.50**
Std Dev	0.0042	0.0034	0.0023	0.0029	0.0018	0.0008	0.0018	0.08
$C_{(95\%)}$	0.0032	0.0020	0.0014	0.0018	0.0014	0.0005	0.0010	0.06

Note: $C_{(95\%)}$ is the 95% half-width confidence interval derived from the equation:

$$C_{(95\%)} = (t \times SD)/\sqrt{n}$$

where n is the number of available values, t is the Student's t value for n-1 degrees of freedom, and SD is the standard deviation of the test results.

Participating Laboratories

Exova Ltd.	Middlesbrough, UK	UKAS	accreditation	0239
Sheffield Analytical Services	Sheffield, UK	UKAS	accreditation	0012
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA	accreditation	0492
Genitest Inc.	Montreal, QC, Canada	PRI	accreditation	123077
Luo Yang Copper	Luo Yang, He Nan, China	CNAL	accreditation	0173
Shanghai JinYi Test Technology Co. Ltd	Shanghai, China	CNAL	accreditation	0783
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS	accreditation	1461
Bureau Veritas CPS Ltd.	Chennai, India	NABL	accreditation	0025
TCR Engineering Services PVT. Ltd.	Mumbai, India	NABL	accreditation	0367
Raghavendra Spectro Metallurgical Laboratory	Bangalore, India	NABL	accreditation	0371
Institute of Non-ferrous Metals	Gliwice, Poland	PCA	accreditation	AB274
TEC Eurolab SRL	Modena, Italy	ACCREDIA	accreditation	52
AMG Superalloys UK Ltd	Rotherham, UK			
Analyticka Laborator Lithea sro	Brno, Czech Republic			
Colonial Metal Co.	Columbia, PA, USA			
Coleshill Laboratories Ltd	Coleshill, UK			

Note: to achieve the above accreditation (eg UKAS, NATA, etc), test houses must demonstrate conformity to the general requirements of EN ISO/IEC 17025.

Analytical Methods Used

ELEMENT	RESULT No. & METHOD				
	ICP-AES	XRF	FAAS	OTHER	
Tin	1, 2, 4, 5, 7, 9	-	6, 8, 10	3	photometric (phenyl fluorone)
Lead	2, 4-6, 8-13	-	1, 3, 7		
Zinc	1, 3, 4, 7-12	-	2, 5, 6		
Iron	1, 3, 4, 6-9, 13	10	11	2, 12	photometric (orthophenanthroline)
				5	volumetric (dichromate)
Nickel	3, 6-11, 13, 14	12	2	1	photometric (dimethyl glyoxime)
				4, 5	gravimetric (dimethyl glyoxime)
Aluminium	1, 2, 4-6, 8	10	3, 7, 12	9, 11	volumetric (EDTA)
Silicon	1, 2, 4, 6, 8, 9	-	-	3	photometric (molybdenum blue)
				5, 7	gravimetric (perchloric acid)
Arsenic	1-6, 9-12, 14	-	7, 8	13	photometric (turbidity)
Phosphorus	3, 4, 7, 9	-	-	1, 2	photometric (molybdenum yellow)
				5, 6, 8	volumetric (alkalimetric)
Manganese	1-6, 9, 10, 13	12	8, 11	7	photometric (periodate)
Cobalt	1-3, 5, 6, 8-10, 12	11	4, 7		
Chromium	1, 3, 4, 6, 7, 10-12	-	2, 5, 8, 9		
Niobium	1, 3-7, 9	-	2, 8		
Magnesium	1-6, 8, 10-13	-	7, 9, 14		
Silver	1, 2, 4, 7-12, 14	-	3, 5, 6, 13		
Copper	1, 7, 8	-	-	4, 9	electro-gravimetric
				2, 3, 5, 6, 10	volumetric (thiosulfate)

Notes

This Certified Reference Material has been produced and certified in accordance with the requirements of ISO Guide 34-2009, ISO Guide 31-2015 and ISO Guide 35-2006, taking into account the requirements of the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

The unidirectional solidification effects associated with this method of chill casting, have led to the formation of inhomogeneous segregates in the rear portion of the disc. The above certification is therefore only applicable from the front face of the disc. Material to the rear of the disc, to a depth of ~3 mm, is not certified.

This material will remain stable provided adequate precautions are taken to protect it from cross-contamination, extremes of temperature and atmospheric moisture. All production records will be retained for a period of 20 years from the date of this certificate. Technical support for this certification will therefore expire in June 2036, although we reserve the right to make changes as issue revisions, in the intervening period.

This material is also available in the form of chippings

The manufacture, analysis and certification of this product were supervised by L Maxim, Technical Director, MBH Analytical Ltd.

The material to which this certificate of analysis refers is supplied subject to our general conditions of sale.