MBH ANALYTICAL LTD

HOLLAND HOUSE • QUEENS ROAD • BARNET • EN5 4DJ • ENGLAND • TEL: +44 (0)20 8441 2024 • FAX: +44 (0)20 8449 0810

email: info@mbh.co.uk web: www.mbh.co.uk

CERTIFICATE OF ANALYSIS

32X SN6 (batch B)

Certified Reference Material Information

Type:	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	As	Cd
Value [1]	**6.78**	**1.644**	**2.00**	**0.376**	**0.295**	**0.059**	**0.804**	**0.0242**
Uncertainty [2]	0.04	0.012	0.03	0.009	0.002	0.003	0.010	0.0007

Element	Mn	Cr	Co	Bi	Sb	Ag	Au	Cu
Value [1]	**0.090**	**0.015**	**0.750**	**0.127**	**0.304**	**1.007**	**0.0027**	**85.73**
Uncertainty [2]	0.002	0.002	0.008	0.003	0.003	0.013	0.0002	0.10

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 13th July 2018

MBH ANALYTICAL LIMITED _____

C Eveleigh

Method of Preparation

This reference material was produced from commercial-purity metals, 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

Samples for chemical analysis were taken from various positions throughout the casting process. At least 15% of all discs were selected for non-destructive homogeneity testing.

Homogeneity

Samples representative of the batch were checked for uniformity using an optical emission spectrometer.

From this test data, through-batch variation values were derived for each element as an indicator of any minor compositional variation (as determined for the specific sample size and other limitations of 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, 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, described 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.

Of the individual results herein, some have traceability (to the mole) via primary analytical methods. Some are traceable to substances of known stoichiometry. Most have traceability via commercial solutions. Furthermore, some results have additional 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. 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	As	Cd
1	6.686	1.620	1.955	0.3621	0.2864	0.0550	0.7831	0.0220
2	6.720	1.621	1.957	0.3652	0.2887	0.0556	0.7850	0.0230
3	6.737	1.630	1.961	0.3668	0.2902	0.0558	0.7870	0.0234
4	6.756	1.633	1.975	0.3678	0.2910	0.0568	0.7995	0.0235
5	6.762	1.637	1.975	0.3703	0.2920	0.0573	0.8004	0.0236
6	6.783	1.644	1.988	0.3748	0.2928	0.0585	0.8010	0.0236
7	6.788	1.644	1.994	0.3754	0.2936	0.0587	0.8011	0.0239
8	6.802	1.645	1.998	0.3758	0.2950	0.0590	0.8050	0.0240
9	6.804	1.651	2.020	0.3770	0.2955	0.0606	0.8055	0.0243
10	6.804	1.652	2.024	0.3770	0.2957	0.0609	0.8060	0.0245
11	6.820	1.657	2.026	0.3790	0.2960	0.0610	0.8084	0.0245
12	6.834	1.658	2.042	0.3900	0.2970	0.0611	0.8160	0.0247
13	6.847	1.658	2.045	0.3940	0.2974	0.0622	0.8207	0.0248
14		1.662	2.054	0.3942	0.2979	0.0624	0.8222	0.0255
15					0.3000			0.0258
16					0.3030			0.0264
Mean	**6.780**	**1.644**	**2.001**	**0.3764**	**0.2945**	**0.0589**	**0.8036**	**0.0242**
Std Dev	0.046	0.014	0.034	0.0102	0.0043	0.0025	0.0127	0.0011
$C_{(95\%)}$	0.028	0.008	0.020	0.0059	0.0023	0.0015	0.0073	0.0006

Sample	Mn	Cr	Co	Bi	Sb	Ag	Au	Cu
1	0.0869	0.0126	0.7291	0.1225	0.2938	0.975	0.0022	85.51
2	0.0870	0.0134	0.7320	0.1231	0.2998	0.980	0.0025	85.54
3	0.0887	0.0140	0.7360	0.1240	0.3005	0.989	0.0026	85.62
4	0.0892	0.0144	0.7360	0.1243	0.3008	0.994	0.0027	85.70
5	0.0893	0.0150	0.7431	0.1254	0.3020	0.994	0.0027	85.76
6	0.0899	0.0154	0.7480	0.1269	0.3030	1.002	0.0028	85.78
7	0.0903	0.0157	0.7520	0.1280	0.3032	1.002	0.0028	85.81
8	0.0907	0.0157	0.7590	0.1303	0.3040	1.005	0.0029	85.82
9	0.0908	0.0160	0.7591	0.1330	0.3050	1.005	0.0033	85.85
10	0.0914	0.0160	0.7595	0.1331	0.3050	1.007		85.88
11	0.0915	0.0166	0.7610		0.3050	1.026		
12	0.0917	0.0169	0.7630		0.3061	1.033		
13	0.0921		0.7664		0.3102	1.043		
14					0.3124	1.046		
Mean	**0.0900**	**0.0151**	**0.7496**	**0.1271**	**0.3036**	**1.007**	**0.0027**	**85.73**
Std Dev	0.0017	0.0013	0.0130	0.0039	0.0045	0.022	0.0003	0.13
$C_{(95\%)}$	0.0010	0.0008	0.0078	0.0028	0.0026	0.013	0.0002	0.09

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, England	UKAS accreditation 0239
Sheffield Assay Office	Sheffield, England	UKAS accreditation 0012
Anchorcert Analytical	Birmingham, England	UKAS accreditation 0667
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Shanghai Jinyi Test Technology Co	Shanghai, China	CNAL accreditation 0783
Luo Yang Copper	Luo Yang, He Nan, China	CNAL accreditation 0173
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS accreditation 1461
Raghavendra Spectromet Laboratory	Bangalore, India	NABL accreditation 0371
TCR Engineering Services Pvt Ltd	Mumbai, India	NABL Accreditation 0367
Institute of Non-Ferrous Metals	Gliwice, Poland	PCA accreditation AB274
TEC-Eurolab SRL	Modena, Italy	Accredia accreditation 52
INCDMNR-IMNR	Pantelimon, Romania	
Mineral & Metallurgical Laboratories	Bangalore, India	
AMG Superalloys UK Ltd	Rotherham, England	
Analyticka Laborator Lithea sro	Brno, Czech Republic	

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

Analytical Methods Used

ELEMENT	RESULT No. & METHOD			
	ICP-AES	FAAS	OTHER	
Tin	1, 3, 4, 6, 8-12	13	2, 7	volumetric (iodate)
			5	photometric (phenyl fluorone)
Lead	1, 4-8, 10, 12, 13	2, 3, 9, 14	11	gravimetric (sulfate)
Zinc	1-3, 5-8, 10, 12	4, 9, 11, 13	14	volumetric (EDTA
Iron	1-6, 8, 12, 13	9, 14	7, 10	photometric (o-phenanthroline)
			11	volumetric (redox)
Nickel	1, 3, 5, 7-14	2, 15, 16	4	gravimetric (dimethyl glyoxime)
			6	photometric (dimethyl glyoxime)
Aluminium	1, 3-10, 14	2, 11	12	photometric (chrome azurol S)
			13	volumetric (EDTA)
Arsenic	1-7, 9, 11-13	8, 14	10	photometric (turbidity)
Cadmium	2-7, 9, 10, 12, 13, 16	1, 8, 11, 15	14	gravimetric
Manganese	1, 2, 5, 7-13	3, 4	6	volumetric (arsenite)
Chromium	1-12			
Cobalt	1, 2, 4-7, 9-13	2, 3	8	gravimetric
Bismuth	1, 2, 4-6, 8, 10	7	3	photometric (iodide)
			9	gravimetric
Antimony	1, 2, 4, 5, 7, 8, 10, 11, 13, 14	3, 6	9	volumetric (permanganate)
			12	photometric (crystal violet)
Silver	1-3, 5, 8-11, 14	4, 7, 12, 13	6	gravimetric (chloride)
Gold	3, 5-9	1, 2, 4		
Copper	5, 7, 9	-	1-3, 8	volumetric (thiosulfate)
			4, 6, 10	electrogravimetric

Notes

This Certified Reference Material has been produced and certified in accordance with the requirements of ISO Guide 34, ISO Guide 31 and ISO Guide 35, 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 to a depth of 10mm. Material to the rear of the disc, to a depth of ~5mm, is not certified.

This material will remain stable indefinitely, 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. This certification will therefore expire in July 2038, although we reserve the right to make changes as issue revisions, in the intervening period.

This product is also available in the form of chippings, for the monitoring and calibration of wet analytical techniques.

The manufacture, analysis and certification of this product were supervised by C Eveleigh, PhD, Technical Director, MBH Analytical Ltd.

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