MBH ANALYTICAL LTD

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CERTIFICATE OF ANALYSIS

32X SN5 (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	Cr	Mn
Value [1]	**15.90**	**0.860**	**0.604**	**1.009**	**0.667**	**0.215**	**0.0557**	**0.0238**	**0.528**
Uncertainty [2]	0.10	0.006	0.005	0.014	0.009	0.006	0.0008	0.0015	0.005

Element	Co	Bi	Sb	Au	Ag	Cd	Te	Cu
Value [1]	**0.129**	**0.124**	**0.702**	**0.0102**	**0.095**	**0.130**	**(0.001)**	**78.97**
Uncertainty [2]	0.003	0.003	0.005	0.0004	0.003	0.003	-	0.13

Note: values given in parentheses are not certified - they are provided for information only.

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 5th March 2016

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

The discs were checked for sample and batch uniformity using an optical emission spectrometer.

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, 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. 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. 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	Cr	Mn
1	15.76	0.8482	0.5908	0.985	0.6455	0.1990	0.0539	0.0201	0.5150
2	15.77	0.8483	0.5970	0.986	0.6518	0.2000	0.0539	0.0209	0.5150
3	15.77	0.8534	0.5980	0.997	0.6574	0.2003	0.0547	0.0215	0.5197
4	15.79	0.8570	0.5990	0.999	0.6590	0.2059	0.0548	0.0218	0.5220
5	15.80	0.8596	0.5996	1.002	0.6608	0.2155	0.0550	0.0221	0.5240
6	15.82	0.8606	0.6015	1.009	0.6620	0.2180	0.0551	0.0232	0.5253
7	15.85	0.8609	0.6021	1.010	0.6630	0.2190	0.0552	0.0242	0.5271
8	15.89	0.8610	0.6024	1.012	0.6650	0.2191	0.0552	0.0245	0.5291
9	15.98	0.8612	0.6030	1.014	0.6665	0.2200	0.0559	0.0248	0.5305
10	16.00	0.8614	0.6032	1.015	0.6670	0.2214	0.0560	0.0251	0.5310
11	16.02	0.8620	0.6087	1.023	0.6680	0.2246	0.0566	0.0251	0.5320
12	16.02	0.8620	0.6100	1.026	0.6741	0.2250	0.0567	0.0252	0.5320
13	16.05	0.8630	0.6110	1.038	0.6766	0.2275	0.0583	0.0252	0.5345
14	16.05	0.8678	0.6113		0.6801		0.0585	0.0254	0.5350
15		0.8680	0.6143		0.6850			0.0255	0.5352
16		0.8732	0.6157		0.6860			0.0257	0.5363
Mean	**15.90**	**0.8604**	**0.6042**	**1.009**	**0.6667**	**0.2150**	**0.0557**	**0.0238**	**0.5277**
Std Dev	0.12	0.0066	0.0069	0.015	0.0113	0.0102	0.0014	0.0019	0.0070
$C_{(95\%)}$	0.07	0.0035	0.0037	0.009	0.0060	0.0061	0.0008	0.0010	0.0037

Sample	Co	Bi	Sb	Au	Ag	Cd	Te	Cu
1	0.1250	0.1150	0.6970	0.0094	0.0865	0.1260	0.0005	78.76
2	0.1252	0.1195	0.6980	0.0095	0.0910	0.1264	0.0008	78.78
3	0.1263	0.1204	0.6986	0.0098	0.0915	0.1270	0.0009	78.87
4	0.1273	0.1206	0.7004	0.0100	0.0919	0.1270	0.0010	78.90
5	0.1280	0.1208	0.7007	0.0100	0.0950	0.1288	0.0011	78.95
6	0.1290	0.1210	0.7009	0.0102	0.0950	0.1289	0.0012	78.98
7	0.1290	0.1213	0.7010	0.0103	0.0966	0.1293	0.0013	79.03
8	0.1293	0.1220	0.7020	0.0105	0.0985	0.1298	0.0015	79.03
9	0.1300	0.1236	0.7028	0.0106	0.1005	0.1302		79.19
10	0.1302	0.1243	0.7030	0.0108	0.1006	0.1303		79.20
11	0.1305	0.1283	0.7031	0.0114		0.1310		
12	0.1309	0.1286	0.7045			0.1310		
13	0.1310	0.1290	0.7050			0.1312		
14	0.1317	0.1292	0.7056			0.1317		
15	0.1320	0.1307	0.7060			0.1320		
16		0.1325				0.1320		
Mean	**0.1290**	**0.1242**	**0.7019**	**0.0102**	**0.0947**	**0.1295**	**0.0010**	**78.97**
Std Dev	0.0022	0.0049	0.0028	0.0006	0.0045	0.0020	0.0003	0.15
$C_{(95\%)}$	0.0012	0.0026	0.0015	0.0004	0.0032	0.0011	0.0003	0.11

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
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Genitest, Inc	Montreal, Canada	PRI accreditation 123077
Shanghai Jinyi Test Technology Co	Shanghai, China	CNAL accreditation 0783
Luo Yang Copper Co	Luo Yang, He Nan, China	CNAL accreditation 0173
Raghavendra Spectromet Laboratory	Bangalore, India	NABL accreditation 0371
Bureau Veritas CPS Pvt	Chennai, India	NABL accreditation 0025
Tec-Eurolab	Campogalliano, Italy	ACCREDIA accreditation 52
Institute of Non-Ferrous Metals	Gliwice, Poland	PCA accreditation AB274
Microlab	Chennai, India	
Mineral & Metallurgical Laboratories	Bangalore, India	
Colonial Metals Co	Columbia, PA, USA	
Coleshill Laboratories Ltd	Birmingham, England	
AMG Superalloys UK Ltd	Rotherham, England	
Analyticka Laborator Lithea, sro	Brno, Czech Republic	

Note: to achieve the above accreditation (UKAS, NATA, etc), test houses are required to 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, 4, 6, 7, 10	3	-	2	photometric (phenyl fluorone)
				5, 9	gravimetric (cupferron)
				8, 11-13	volumetric (iodate)
Lead	1-8, 10, 11, 14, 16	-	9, 13, 15	12	gravimetric (sulfate)
Zinc	1, 2, 4-6, 10, 11, 14-16	12	3, 7, 13	8, 9	volumetric (EDTA)
Iron	1, 4-6, 9, 10, 12, 13	-	3, 7	2, 8	photometric (orthophenanthroline)
				11	volumetric (dichromate)
Nickel	1-5, 7, 9, 12, 13, 15, 16	15	6, 10, 14	8	gravimetric (dimethyl glyoxime)
				11	photometric (dimethyl glyoxime)
Aluminium	2, 4-8, 10, 11, 13	-	1, 3	9	photometric (chrome azurol S)
				12	volumetric (EDTA)
Arsenic	1-8, 11, 12, 14	9	10, 13		
Chromium	1, 3, 4, 6-8, 10-13, 15, 16	-	2, 5, 9	14	volumetric (permanganate)
Manganese	1-3, 6, 7, 9, 10, 12-14, 16	11	4, 5	8	photometric (periodate)
				15	volumetric (arsenite)
Cobalt	1, 3, 7-11, 14, 15	6	2, 4, 5, 12	13	gravimetric (oxide)
Bismuth	1-10, 13, 14, 16	-	12, 15	11	photometric (iodide)
Antimony	1, 3-6, 9, 12-15	10	7, 11	2	photometric (crystal violet)
				8	volumetric (permanganate)
Gold	1-3, 5-11	-	4		
Silver	1, 5-8, 10	2	3, 4, 9		
Cadmium	1, 3, 5-10, 12-15	-	2, 4, 15, 16	11	gravimetric (molybdate)
Tellurium	2-8	-	1		
Copper	4	-	-	6-9	electrogravimetric
				1-3, 5, 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 to a depth of 12mm. Material to the rear of the disc, to a depth of ~3mm, 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 March 2036, although we reserve the right to make changes as issue revisions, in the intervening period.

This sample is also available in the form of chippings.

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.