MBH ANALYTICAL LTD

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CERTIFICATE OF ANALYSIS

36X CN5 (batch P)

Certified Reference Material Information

Type:	CUPRO-NICKEL (CHILL CAST)
Form and Size:	Disc ~40mm diameter
Produced by:	Polycast Ltd
Certified and supplied by:	MBH Analytical Ltd

Assigned Values

Percentage element by weight

Element	Sn	Pb	Fe	Ni	Co	Si	Mn	Cr	Nb
Value [1]	**0.0090**	**0.0120**	**0.347**	**31.03**	**0.0238**	**0.689**	**0.217**	**0.141**	**0.430**
Uncertainty [2]	0.0007	0.0008	0.003	0.11	0.0010	0.014	0.003	0.003	0.004

Element	P	S	C	Mg	Ti	Zn	Be	B	Cu
Value [1]	**0.034**	**0.088**	**(0.008)**	**0.0106**	**0.0203**	**0.209**	**0.0035**	**0.0053**	**66.67**
Uncertainty [2]	0.002	0.003	-	0.0010	0.0008	0.006	0.0002	0.0003	0.06

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

Definitions

[1] The assigned 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 December 2014

MBH ANALYTICAL LIMITED _____

C Eveleigh

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

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, 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. 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	Fe	Ni	Co	Si	Mn	Cr	Nb
1	0.0077	0.0102	0.337	30.91	0.0212	0.664	0.209	0.133	0.424
2	0.0077	0.0105	0.342	30.91	0.0214	0.665	0.211	0.136	0.425
3	0.0078	0.0108	0.343	30.92	0.0222	0.667	0.212	0.136	0.425
4	0.0079	0.0110	0.343	31.02	0.0224	0.667	0.213	0.136	0.426
5	0.0081	0.0113	0.343	31.07	0.0230	0.679	0.214	0.138	0.427
6	0.0087	0.0120	0.343	31.08	0.0232	0.695	0.214	0.139	0.427
7	0.0090	0.0123	0.346	31.09	0.0232	0.699	0.214	0.141	0.429
8	0.0095	0.0125	0.346	31.20	0.0232	0.705	0.216	0.143	0.436
9	0.0096	0.0127	0.348		0.0235	0.709	0.219	0.145	0.438
10	0.0097	0.0129	0.348		0.0236	0.711	0.219	0.145	0.438
11	0.0101	0.0134	0.350		0.0240	0.715	0.220	0.146	
12	0.0107	0.0146	0.351		0.0256		0.220	0.146	
13	0.0108		0.351		0.0259		0.222	0.147	
14			0.351		0.0269		0.223	0.147	
15			0.356		0.0271		0.226		
Mean	**0.0090**	**0.0120**	**0.347**	**31.03**	**0.0238**	**0.689**	**0.217**	**0.141**	**0.430**
Std Dev	0.0011	0.0013	0.005	0.11	0.0018	0.021	0.005	0.005	0.006
$C_{(95\%)}$	0.0007	0.0008	0.003	0.09	0.0010	0.014	0.003	0.003	0.004

Sample	P	S	C	Mg	Ti	Zn	Be	B	Cu
1	0.0295	0.0840	0.0071	0.0095	0.0183	0.192	0.0030	0.0046	66.55
2	0.0312	0.0852	0.0075	0.0098	0.0184	0.195	0.0034	0.0050	66.63
3	0.0320	0.0858	0.0078	0.0103	0.0186	0.197	0.0034	0.0051	66.65
4	0.0321	0.0862	0.0079	0.0104	0.0192	0.201	0.0034	0.0051	66.66
5	0.0328	0.0863	0.0080	0.0105	0.0197	0.206	0.0034	0.0051	66.68
6	0.0347	0.0870	0.0090	0.0107	0.0200	0.206	0.0035	0.0052	66.70
7	0.0356	0.0875		0.0107	0.0201	0.209	0.0035	0.0055	66.71
8	0.0367	0.0880		0.0110	0.0204	0.210	0.0036	0.0055	66.71
9	0.0367	0.0883		0.0112	0.0207	0.211	0.0036	0.0056	66.77
10	0.0369	0.0897		0.0112	0.0212	0.211	0.0037	0.0058	
11	0.0372	0.0897		0.0115	0.0214	0.220		0.0061	
12	0.0373	0.0901			0.0215	0.221			
13		0.0905			0.0223	0.221			
14		0.0923			0.0225	0.225			
Mean	**0.0344**	**0.0879**	**(0.008)**	**0.0106**	**0.0203**	**0.209**	**0.0035**	**0.0053**	**66.67**
Std Dev	0.0027	0.0023	-	0.0006	0.0014	0.010	0.0002	0.0004	0.06
$C_{(95\%)}$	0.0017	0.0013	-	0.0004	0.0008	0.006	0.0001	0.0003	0.05

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
Birmingham Assay office	Birmingham, England	UKAS accreditation 0667
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Laboratory Testing, Inc	Hatfield, PA, USA	A2LA accreditation 0117
Genitest, Inc	Montreal, Canada	PRI accreditation 123077
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS accreditation 1461
Bureau Veritas CPS Pvt Ltd	Chennai, India	NABL accreditation 0025
TCR Engineering Services Ltd	Mumbai, India	NABL accreditation 0367
Raghavendra Spectromet Laboratory	Bangalore, India	NABL accreditation 0371
Institute of Non-Ferrous Metals	Gliwice, Poland	PCA accreditation AB274
London & Scandinavian Met Co	Rotherham, England	
Colonial Metals Co	Columbia, PA, USA	
Coleshill Laboratories Ltd	Birmingham, England	
Lithea sro	Brno, Czech Republic	

Note: to achieve the above accreditation (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	2-4, 6, 8-11, 13	-	5, 7, 12	1	volumetric (iodide)
Lead	1, 3, 5-7, 9-12	-	2, 4, 8		
Iron	1-5, 10-15	9	6-8		
Nickel	2, 3, 5	4	-	1, 6-8	gravimetric (dimethyl glyoxime)
Cobalt	2-4, 6-12, 14, 15	-	1, 5, 13		
Silicon	2-4, 7, 8, 10, 11	6	-	1	photometric (molybdenum blue)
				5, 9	gravimetric (perchloric acid)
Manganese	1, 2, 4, 6-8, 10, 12-15	11	3, 5, 9		
Chromium	1, 3-9, 12-14	-	2, 10, 11		
Niobium	1, 3-5, 7-9	6	2, 10		
Phosphorus	1, 3, 4, 6-8, 10-12	-	-	2, 9	volumetric (alkali metric)
				5	photometric (molybdenum yellow)
Sulfur	2, 5, 10	-	-	others	combustion (IR or volumetric detection)
Carbon	-	-	-	all	combustion (IR or volumetric detection)
Magnesium	1-6, 9, 11	-	7, 8, 10		
Titanium	2, 3, 5-14	-	1, 4		
Zinc	1, 3-6, 8, 10-12, 14	2	7, 9	13	volumetric (EDTA)
Beryllium	1-7, 9	-	8	10	ICP-MS
Boron	1-8, 10, 11	-	9		
Copper	2, 4, 8	-	-	1, 3, 6, 7	electrogravimetric
				5, 9	volumetric (thiosulfate)

Notes

This Certified Reference Material has been produced and certified, wherever possible, in accordance with the requirements of ISO Guide 34-2009, ISO Guide 31-2000 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 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. Technical support for this certification will therefore expire in December 2034, 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.