

# CERTIFICATE OF ANALYSIS

**32X ALB2 (batch M)**

## 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	Al	Fe	Ni	P	Si	As
Value <sup>1</sup>	0.104	0.0247	0.272	10.80	3.77	4.84	0.0349	0.221	0.0177
Uncertainty <sup>2</sup>	0.003	0.0011	0.004	0.04	0.03	0.04	0.0015	0.006	0.0010

Element	Co	Mn	Cr	Nb	Ti	Ag	Mg	Te	Cu
Value <sup>1</sup>	0.157	0.321	0.050	0.026	0.0295	0.0230	0.0082	0.0039	79.17
Uncertainty <sup>2</sup>	0.003	0.005	0.002	0.002	0.0015	0.0008	0.0006	0.0003	0.15

## Definitions

- <sup>1</sup> 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.
- <sup>2</sup> The uncertainties are value judgements, based on 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:

MBH ANALYTICAL LIMITED

  
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C Eveleigh

on 25<sup>th</sup> October 2019

## **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, 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.

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.

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	Al	Fe	Ni	P	Si	As
1	0.0960	0.0211	0.2617	10.73	3.703	4.767	0.0320	0.2103	0.0160
2	0.0987	0.0236	0.2640	10.75	3.713	4.773	0.0333	0.2128	0.0165
3	0.1022	0.0242	0.2650	10.76	3.720	4.802	0.0334	0.2130	0.0167
4	0.1027	0.0244	0.2670	10.76	3.747	4.804	0.0341	0.2156	0.0171
5	0.1030	0.0248	0.2684	10.77	3.773	4.816	0.0343	0.2160	0.0176
6	0.1030	0.0253	0.2738	10.78	3.787	4.849	0.0345	0.2180	0.0178
7	0.1040	0.0255	0.2740	10.79	3.792	4.854	0.0348	0.2205	0.0188
8	0.1050	0.0257	0.2742	10.79	3.796	4.855	0.0359	0.2230	0.0193
9	0.1060	0.0260	0.2758	10.83	3.796	4.880	0.0360	0.2272	0.0199
10	0.1061	0.0261	0.2758	10.83	3.797	4.883	0.0362	0.2341	
11	0.1069		0.2770	10.83	3.800	4.920	0.0365	0.2370	
12	0.1082		0.2795	10.85	3.817		0.0372		
13	0.1117		0.2810	10.89	3.818				
<b>Mean</b>	<b>0.1041</b>	<b>0.0247</b>	<b>0.2721</b>	<b>10.80</b>	<b>3.774</b>	<b>4.837</b>	<b>0.0349</b>	<b>0.2207</b>	<b>0.0177</b>
<b>Std Dev</b>	0.0040	0.0015	0.0062	0.05	0.040	0.048	0.0015	0.0088	0.0013
<b>C<sub>(95%)</sub></b>	0.0024	0.0011	0.0037	0.03	0.024	0.032	0.0010	0.0059	0.0010

Sample	Co	Mn	Cr	Nb	Ti	Ag	Mg	Te	Cu
1	0.1490	0.3068	0.0457	0.0222	0.0272	0.0202	0.0074	0.0032	79.01
2	0.1508	0.3080	0.0477	0.0235	0.0280	0.0215	0.0077	0.0035	79.02
3	0.1549	0.3120	0.0478	0.0240	0.0283	0.0215	0.0077	0.0039	79.04
4	0.1553	0.3124	0.0487	0.0254	0.0285	0.0220	0.0077	0.0039	79.09
5	0.1558	0.3160	0.0488	0.0257	0.0288	0.0223	0.0082	0.0040	79.24
6	0.1570	0.3183	0.0489	0.0263	0.0290	0.0223	0.0082	0.0041	79.25
7	0.1580	0.3185	0.0493	0.0265	0.0300	0.0230	0.0084	0.0042	79.28
8	0.1590	0.3197	0.0510	0.0275	0.0303	0.0232	0.0085	0.0042	79.30
9	0.1620	0.3207	0.0516	0.0287	0.0307	0.0233	0.0087		79.32
10	0.1621	0.3240	0.0517	0.0296	0.0308	0.0237	0.0089		
11	0.1628	0.3250	0.0519	0.0306	0.0311	0.0243	0.0090		
12		0.3310	0.0525		0.0318	0.0245			
13		0.3320	0.0526			0.0247			
14		0.3335	0.0535			0.0249			
15		0.3370							
<b>Mean</b>	<b>0.1570</b>	<b>0.3210</b>	<b>0.0501</b>	<b>0.0264</b>	<b>0.0295</b>	<b>0.0230</b>	<b>0.0082</b>	<b>0.0039</b>	<b>79.17</b>
<b>Std Dev</b>	0.0045	0.0094	0.0021	0.0026	0.0014	0.0014	0.0005	0.0004	0.13
<b>C<sub>(95%)</sub></b>	0.0030	0.0052	0.0013	0.0017	0.0009	0.0008	0.0004	0.0003	0.10

Note: C<sub>(95%)</sub> 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

Element Ltd  
Sheffield Analytical Services  
Anchorcert Analytical  
Universal Scientific Laboratory Pty Ltd  
Shanghai Jinyi Test Tech Co  
Luo Yang Copper  
Genitest, Inc  
Raghavendra Spectromet Laboratory  
TCR Engineering Services Ltd  
Tec-Eurolab  
Institute of Non-Ferrous Metals  
Mineral & Metallurgical Laboratories  
INCDMNR-IMNR  
AMG Superalloys UK Ltd  
Analyticka Laborator Lithea sro

Middlesbrough, England  
Sheffield, England  
Birmingham, England  
Milperra, NSW, Australia  
Shanghai, China  
Luo Yang, He Nan, China  
Montreal, Canada  
Bangalore, India  
Mumbai, India  
Campogalliano, Italy  
Gliwice, Poland  
Bangalore, India  
Pantelimon, Romania  
Rotherham, England  
Brno, Czech Republic

UKAS accreditation 0239  
UKAS accreditation 0012  
UKAS accreditation 0667  
NATA accreditation 0492  
CNAS accreditation L0041  
CNAL accreditation 0173  
PJ accreditation L17-153  
NABL accreditation 0371  
NABL accreditation 0367  
ACCREDIA accreditation 52  
PCA accreditation AB274

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	1-5, 8, 10-13	9	6 7 volumetric (iodine) photometric (phenyl fluorone)
Lead	1, 4-9	2, 3, 10	
Zinc	1-6, 8-10, 13	7, 11, 12	
Aluminium	1-3, 5, 7-11, 13	12	4 6 photometric (chrome azurol) volumetric (EDTA)
Iron	1-7, 9-11	13	8 12 photometric (orthophenanthroline) volumetric (redox)
Nickel	1, 3, 4, 6-8, 11	5, 9, 10	2 3 gravimetric (dimethyl glyoxime) volumetric (alkalimetric)
Phosphorus	2, 5, 8-12	-	1, 7 3, 4, 6 photometric (molybdenum yellow) photometric (molybdenum yellow)
Silicon	1, 2, 4, 5, 7, 9-11	-	3 6, 8 gravimetric (perchloric acid) photometric (turbidity)
Arsenic	1, 2, 4-8	3	9
Cobalt	1-5, 8, 10, 11	6, 7, 9	
Manganese	1-4, 6-11, 14, 15	5, 12, 14	13 volumetric (arsenite)
Chromium	1-3, 5, 7, 9-14	6, 8	4 photometric (diphenyl carbazide)
Niobium	1, 3-11	2	
Titanium	1-4, 6-8, 10, 11	9, 12	5 photometric (peroxide)
Silver	1-9, 11, 13	10, 12, 14	
Magnesium	1, 3-8, 10, 11	2, 9	
Tellurium	1, 2, 4-6, 8	3, 7	
Copper	4, 6, 7, 8	-	1, 5, 9 volumetric (thiosulfate) 2, 3 electrogravimetric

## Notes

This Certified Reference Material has been produced and certified, wherever possible, in accordance with the requirements of ISO 17034 and the associated Guides, 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 ~3 mm, 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 October 2039, 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, for the calibration or control of methods involving dissolution.

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.