

CERTIFICATE OF ANALYSIS

36X SP1 (batch A)

Certified Reference Material Information

Type: Cu/Ni/Sn Spinodal Alloy (chill cast)
Form and Size: Disc 40mm Diameter x 15mm Thickness
Produced by: Polycast Limited
Certified and supplied by: MBH Analytical Limited

Certified Analysis

Percentage element by weight

Element	Sn	Pb	Zn	Fe	Ni	Co	Si	Mn	Sb
Value ¹	5.75	0.0115	0.344	0.45	8.33	0.057	0.004	0.084	0.0177
Uncertainty ²	0.05	0.0016	0.008	0.02	0.08	0.002	0.001	0.005	0.0014

Element	Ti	Nb	P	S	Bi	B	Al	Ag	Cu
Value ¹	(0.0004)	(0.031)	(0.003)	0.005	0.0039	0.0007	0.0020	0.005	84.90
Uncertainty ²	-	-	-	0.001	0.0005	0.0002	0.0001	0.001	0.15

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:

MBH ANALYTICAL LIMITED _____

on 31st March 2005

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. Metal was 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 10% 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. One disc was checked for vertical uniformity using the same method.

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 - 2000, 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

Most of the analytical work performed to assess this material has been carried out by laboratories with proven competence, as indicated by their accreditation to a national authority. It is part of the 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 primary reference materials.

Usage

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

Recommended method of use: Cupro-nickels are generally prepared by finishing, turning or milling. 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	Co	Si	Mn	Sb
1	5.64	0.0093	0.326	0.421	8.221	0.0515	0.0027	0.0796	0.0136
2	5.68	0.010	0.331	0.428	8.23	0.0522	0.0028	0.0804	0.0162
3	5.732	0.0100	0.341	0.441	8.27	0.0539	0.0041	0.0817	0.0165
4	5.739	0.0105	0.343	0.448	8.30	0.056	0.0041	0.0828	0.0166
5	5.743	0.0106	0.345	0.450	8.347	0.0563	0.0044	0.084	0.0179
6	5.775	0.0110	0.349	0.456	8.35	0.0570	0.0046	0.0847	0.0183
7	5.780	0.0134	0.35	0.460	8.386	0.0571	0.005	0.085	0.0187
8	5.80	0.014	0.354	0.466	8.400	0.0585	0.0052	0.0893	0.0193
9	5.81	0.0149	0.356	0.469	8.47	0.0590	0.0058	0.0919	0.0200
10	5.84					0.0604			0.0201
11						0.061			
Mean	5.754	0.0115	0.344	0.449	8.330	0.0566	0.0043	0.0844	0.0177
Std Dev	0.061	0.0020	0.010	0.016	0.083	0.0031	0.0010	0.0040	0.0020
C_(95%)	0.043	0.0016	0.008	0.013	0.064	0.0021	0.0008	0.0031	0.0014

Sample	Ti	Nb	P	S	Bi	B	Al	Ag	Cu
1	0.0002	0.0213	0.0008	0.004	0.0031	0.0004	0.0019	0.0040	84.70
2	0.0003	0.024	0.001	0.0042	0.0036	0.0005	0.0020	0.0043	84.79
3	0.00034	0.0259	0.0025	0.0045	0.0040	0.0005	0.0020	0.0046	84.85
4	0.0004	0.0284	0.0025	0.0047	0.0040	0.0006	0.0020	0.0049	84.90
5	0.0005	0.0352	0.003	0.0054	0.0043	0.0009	0.0021	0.0050	84.90
6	0.0006	0.0376	0.0031	0.0059	0.0044	0.0010	0.0021	0.0056	85.07
7	0.0007	0.0386	0.0039	0.0059		0.0010		0.0068	85.12
8		0.0386	0.0055	0.006				0.0074	
9				0.0060					
10				0.0061					
Mean	(0.0004)	0.031	(0.003)	0.0052	0.0039	0.0007	0.0020	0.0053	84.90
Std Dev	-	0.007	-	0.0008	0.0005	0.003	0.0001	0.0012	0.15
C_(95%)	-	0.006	-	0.0006	0.0005	0.0002	0.0001	0.0010	0.14

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

ATI Allvac Ltd	Sheffield, England	UKAS accreditation 0638
Bodycote Materials Testing Ltd	Middlesbrough, England	UKAS accreditation 0239
Sheffield Assay Office	Sheffield, England	UKAS accreditation 0012
Central Iron & Steel Research Inst	Beijing, China	CNAL accreditation 0435
Luo Yang Copper	Luo Yang, He Nan, China	CNAL accreditation 0173
Institute of Iron & Steel Technology	Shanghai, China	CNAL accreditation 0783
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation 492
Laboratory Testing Inc	Hatfield, PA, USA	A2LA accreditation 0117
TCR Engineering Services Ltd	Mumbai, India	NABL accreditation 0367
Brush-Wellman Inc	Elmore, OH, USA	
Genitest Inc	Montreal, Canada	
Coleshill Laboratories Ltd	Coleshill, England	

Note: to achieve National Accreditation (eg UKAS, NATA, CNAL, A2LA, NABL), 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	-	6, 9 7 volumetric (iodide) gravimetric (as oxide)
Lead	1, 4, 5, 7-9	2, 3, 6	
Zinc	2-6, 8	1, 7, 9	
Iron	1, 4-6, 8, 9	2, 7	3 photometric (orthophenanthroline)
Nickel	1, 4, 6, 7	-	2 volumetric (DMGO/EDTA)
Cobalt	1-3, 5, 7-9	4, 6, 10, 11	3, 8 gravimetric (dimethyl glyoxime)
Silicon	1-5, 9	-	5, 9 photometric (dimethyl glyoxime)
Manganese	1-4, 6, 8, 9	5, 7	6-8 photometric (molybdenum blue)
Antimony	1-3, 6-8, 10	4, 5, 9	photometric (periodate)
Titanium	1, 3-7	2	
Niobium	1, 3-8	-	2 photometric (4, 2-pyridylazo resorcinol)
Phosphorus	1, 3, 4, 6, 8	-	2, 5, 7 photometric (molybdenum yellow)
Sulfur	-	-	all combustion (infra-red detection)
Bismuth	1, 3-5	2	6 photometric (iodide)
Boron	1-3, 5-7	-	4 photometric (circumin, dianthrimide)
Aluminium	1, 3, 4, 6	5	2 photometric (chrome azurol-S)
Silver	3-5, 7, 8	1, 2, 6	
Copper	1	-	3-5 electrogravimetric
			6, 7 volumetric (thiosulphate)
			2 photometric (BCO)

Notes

This Certified Reference Material has been produced and certified in accordance with the requirements of ISO Guide 34-2000, ISO Guide 31-2000 and ISO Guide 35-1989, taking into account the requirements of ASTM E1724, ASTM E1831 and the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

The combination of alloying elements used in a complex material of this type, coupled with 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. Material to the rear of the disc, to a depth of ~5mm, 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. This certification will therefore expire in March 2025, although we reserve the right to make changes as issue revisions, in the intervening period.

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.