

CERTIFICATE OF ANALYSIS

119X COB1 (batch H)

Certified Reference Material Information

Type: COBALT-BASE ALLOY (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	C	Si	S	Mn	Ni	Cr	Nb
Value ¹	0.0520	0.493	0.0099	0.514	22.14	24.62	0.405
Uncertainty ²	0.0016	0.011	0.0004	0.008	0.11	0.13	0.007

Element	Mo	W	Fe	Al	P	Cu	N
Value ¹	0.413	11.99	15.15	0.055	0.0192	0.0607	0.093
Uncertainty ²	0.010	0.06	0.15	0.005	0.0007	0.0008	0.005

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 17th January 2017

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

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. The testing procedure was in accordance with ASTM E826 and the material found acceptable.

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 - 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.

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: Cobalt alloys are generally prepared by finishing, grinding, 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.

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	C	Si	S	Mn	Ni	Cr	Nb
1	0.0500	0.4644	0.0090	0.4970	21.905	24.432	0.3950
2	0.0501	0.4706	0.0094	0.5000	22.000	24.450	0.3968
3	0.0502	0.4780	0.0098	0.5004	22.019	24.500	0.3989
4	0.0503	0.4878	0.0098	0.5049	22.033	24.511	0.3998
5	0.0514	0.4880	0.0099	0.5072	22.099	24.520	0.4012
6	0.0528	0.5004	0.0100	0.5099	22.100	24.532	0.4075
7	0.0529	0.5011	0.0100	0.5174	22.106	24.610	0.4120
8	0.0532	0.5028	0.0100	0.5177	22.143	24.693	0.4120
9	0.0533	0.5060	0.0100	0.5193	22.234	24.729	0.4216
10	0.0534	0.5072	0.0101	0.5250	22.289	24.766	
11	0.0540	0.5176	0.0102	0.5252	22.387	24.780	
12			0.0105	0.5280	22.420	24.870	
13				0.5300			
Mean	0.0520	0.4931	0.0099	0.5140	22.145	24.616	0.4050
Std Dev	0.0016	0.0167	0.0004	0.0114	0.158	0.146	0.0088
C_(95%)	0.0011	0.0112	0.0002	0.0069	0.101	0.093	0.0068

Sample	Mo	W	Fe	Al	P	Cu	N
1	0.3880	11.857	15.050	0.0497	0.0168	0.0590	0.0856
2	0.4004	11.860	15.060	0.0519	0.0173	0.0593	0.0885
3	0.4008	11.953	15.066	0.0520	0.0179	0.0601	0.0889
4	0.4017	11.969	15.110	0.0541	0.0190	0.0603	0.0925
5	0.4020	11.971	15.110	0.0542	0.0191	0.0604	0.0931
6	0.4041	12.016	15.120	0.0545	0.0191	0.0605	0.0988
7	0.4130	12.020	15.164	0.0560	0.0195	0.0607	0.0990
8	0.4186	12.020	15.210	0.0569	0.0197	0.0607	0.1010
9	0.4225	12.036	15.220	0.0582	0.0197	0.0616	
10	0.4317	12.044	15.235	0.0616	0.0198	0.0622	
11	0.4339	12.051	15.281	0.0618	0.0198	0.0624	
12	0.4350	12.104			0.0201		
13					0.0212		
Mean	0.4126	11.992	15.148	0.0555	0.0192	0.0607	0.0934
Std Dev	0.0155	0.074	0.079	0.0039	0.0012	0.0011	0.0057
C_(95%)	0.0099	0.047	0.053	0.0026	0.0007	0.0007	0.0047

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, UK	UKAS accreditation	0239
Sheffield Analytical Services	Sheffield, UK	UKAS accreditation	0012
Laboratory Testing, Inc.	Hatfield, PA, USA	A2LA accreditation	0117
Genitest Inc.	Montreal, QC, Canada	PRI accreditation	123077
Shanghai JinYi Test Technology Co. Ltd	Shanghai, China	CNAL accreditation	0783
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS accreditation	1461
Bureau Veritas CPS Ltd	Chennai, India	NABL accreditation	0025
TCR Engineering Services PVT. Ltd	Mumbai, India	NABL accreditation	0367
Raghavendra Spectro Metallurgical Laboratory	Bangalore, India	NABL accreditation	0371
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA accreditation	AB554
TEC Eurolab SRL	Modena, Italy	ACCREDIA accreditation	52
Mineral and Metallurgical Laboratories	Bangalore, India		
AMG Superalloys UK Ltd	Rotherham, UK		
Analyticka Laborator Lithea sro	Brno, Czech Republic		
Coleshill Laboratories Ltd	Coleshill, UK		

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
Carbon	-	-	1-11 combustion (infra-red detection)
Silicon	1, 2, 7, 8, 11	-	3, 5 photometric (molybdenum blue)
Sulfur	8, 11	-	4, 6, 9-10 gravimetric (perchloric acid)
Manganese	3-9, 12	13	1-7, 9, 10, 12 combustion (IR or volumetric detection)
Nickel	1-3, 8, 10-12	-	1, 2 volumetric (arsenite, FAS)
Chromium	2, 3, 5, 8, 10-12	-	10-11 photometric (periodate)
Niobium	1-6, 9	-	4, 6, 9 gravimetric (dimethyl glyoxime)
Molybdenum	2-4, 6-11	-	5 photometric (dimethyl glyoxime)
Tungsten	1, 2, 5-8, 10-11	-	7 volumetric (dimethyl glyoxime, EDTA)
Iron	4-6, 8, 11	2	1, 4, 6, 7, 9 volumetric (ferrous ammonium sulfate)
Aluminium	2-7, 9-11	-	7 photometric (chlorosulfophenol)
Phosphorus	1-6, 9-11	-	8 gravimetric (N-benzoyl, N-PH)
Copper	3-6, 8, 9, 11	2, 7	1, 12 photometric (thiocyanate)
Nitrogen	-	-	5 gravimetric (α -benzoic oxime)
			3, 4 photometric (thiocyanate)
			9, 12 gravimetric (cinchonine)
			1, 3, 7, 9-10 volumetric (dichromate)
			1, 8 photometric (chrome azurol S)
			7, 12 photometric (molybdenum blue)
			8, 13 volumetric (alkalimetric)
			1 photometric (BCO)
			10 volumetric (thiosulfate)
			1, 5, 6, 8 volumetric (hydrochloric acid)
			2-4, 7 inert gas fusion (thermal conductivity)

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. Material to the rear of the disc, to a depth of ~3 mm, 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. Technical support for this certification will therefore expire in January 2037, 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.