MBH ANALYTICAL LTD

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CERTIFICATE OF ANALYSIS

212X 4003 (batch K)

Certified Reference Material Information

Type:	NICKEL/COPPER MONEL-TYPE (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	P	Mn	Cu	Fe	Nb
Value [1]	**0.036**	**0.245**	**0.0257**	**0.0059**	**1.105**	**30.13**	**2.63**	**0.150**
Uncertainty [2]	0.002	0.004	0.0010	0.0006	0.012	0.10	0.03	0.003

Element	Cr	Mo	Ti	Co	Al	Mg	Pb	Ni
Value [1]	**0.097**	**0.0317**	**0.0201**	**0.0286**	**0.010**	**0.050**	**0.053**	**(65.3)**
Uncertainty [2]	0.003	0.0010	0.0012	0.0015	0.001	0.002	0.003	-

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 6th June 2013

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, 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:	Nickel-base alloys are generally prepared by linishing, milling, turning or polishing. 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 OES, 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	P	Mn	Cu	Fe	Nb
1	0.0294	0.237	0.0243	0.0051	1.082	30.01	2.591	0.142
2	0.0322	0.239	0.0250	0.0055	1.083	30.02	2.594	0.148
3	0.0336	0.242	0.0252	0.0056	1.093	30.08	2.625	0.149
4	0.0338	0.243	0.0257	0.0056	1.099	30.11	2.628	0.150
5	0.0350	0.244	0.0259	0.0060	1.106	30.16	2.636	0.151
6	0.0354	0.246	0.0259	0.0060	1.111	30.17	2.642	0.151
7	0.0377	0.247	0.0260	0.0061	1.113	30.19	2.648	0.151
8	0.0380	0.247	0.0261	0.0061	1.115	30.21	2.664	0.151
9	0.0383	0.248	0.0261	0.0063	1.118	30.22	2.671	0.151
10	0.0395	0.250	0.0267	0.0064	1.125			0.158
11	0.0409	0.257						
Mean	**0.0358**	**0.245**	**0.0257**	**0.0059**	**1.105**	**30.13**	**2.633**	**0.150**
Std Dev	0.0034	0.005	0.0007	0.0004	0.015	0.08	0.028	0.004
C (95%)	0.0023	0.004	0.0005	0.0003	0.011	0.06	0.021	0.003

Sample	Cr	Mo	Ti	Co	Al	Mg	Pb	Ni
1	0.0919	0.0295	0.0170	0.0258	0.0081	0.0476	0.0494	65.11
2	0.0922	0.0311	0.0179	0.0260	0.0091	0.0478	0.0505	65.17
3	0.0929	0.0312	0.0180	0.0265	0.0091	0.0486	0.0508	65.29
4	0.0933	0.0317	0.0190	0.0277	0.0093	0.0493	0.0513	65.38
5	0.0949	0.0320	0.0195	0.0278	0.0095	0.0505	0.0527	65.40
6	0.0974	0.0322	0.0199	0.0282	0.0100	0.0509	0.0545	
7	0.0978	0.0323	0.0200	0.0289	0.0100	0.0510	0.0564	
8	0.0997	0.0325	0.0204	0.0289	0.0106	0.0510	0.0565	
9	0.1000	0.0326	0.0205	0.0300	0.0106	0.0511		
10	0.1020		0.0208	0.0306	0.0112	0.0514		
11	0.1020		0.0221	0.0311	0.0112			
12	0.1035		0.0224	0.0312				
13			0.0238					
Mean	**0.0973**	**0.0317**	**0.0201**	**0.0286**	**0.0099**	**0.0499**	**0.0528**	**65.27**
Std Dev	0.0042	0.0010	0.0019	0.0019	0.0010	0.0015	0.0027	0.13
C (95%)	0.0027	0.0007	0.0012	0.0012	0.0007	0.0010	0.0023	0.16

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
Metals Technology (Testing) Ltd	Sheffield, England	UKAS accreditation 0963
Sheffield Assay Office	Sheffield, England	UKAS accreditation 0012
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Genitest, Inc	Montreal, QC, Canada	PRI accreditation 123077
Institute of Iron & Steel Technology	Shanghai, China	CNAL accreditation 0783
Sargam Metals Pvt Ltd	Chennai, India	NABL accreditation 0025
Raghavendra Spectromet Laboratory	Bangalore, India	NABL accreditation 0371
TCR Engineering Services Ltd	Mumbai, India	NABL accreditation 0367
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA accreditation AB554
Tec-Eurolab	Campogalliano, Italy	ACCREDIA accreditation 52
LECO Corporation	St Joseph, MI, USA	
Coleshill Laboratories Ltd	Birmingham, England	
London & Scandinavian Met Co	Rotherham, England	

Note: to achieve the above accreditation (eg 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	GD-AES	FAAS	OTHER	
Carbon	-		-	all	combustion (infra-red detection)
Silicon	1, 2, 4-6, 8, 10, 11	3	-	7, 9	gravimetric (perchloric acid)
Sulfur	6, 8	-	-	1-5, 7, 9, 10	combustion (infra-red detection)
Phosphorus	2-4, 6-10	-	-	1	photometric (molybdenum blue)
				5	photometric (alkalimetric)
Manganese	1, 2, 5, 6, 8, 10	9	4	7	volumetric (arsenite)
				3	photometric (periodate)
Copper	1, 2, 4, 6, 8	-	-	5, 9	electrogravimetric
				7	volumetric (thiosulfate)
				3	photometric (BCO)
Iron	1, 3-7, 9	-	-	2, 8	volumetric (dichromate)
Niobium	1-4, 7-10	-	-	5	ICP-MS
				6	photometric (chlorosulfophenol)
Chromium	1-3, 5-9, 11, 12	10	4		
Molybdenum	1-4, 6, 8, 9	5	-	7	photometric (thiocyanate)
Titanium	1, 2, 5, 6, 8-11, 13	3	4	7	photometric (diantipyryl methane)
				12	ICP-MS
Cobalt	1, 3, 5, 6, 8-12	2	4, 7		
Aluminium	2, 3, 5, 7, 9-11	4	1, 8	6	photometric (chrome azurol S)
Magnesium	1-5, 7-10	-	6		
Lead	1, 3-7	-	2, 8		
Nickel	4	-	-	1	volumetric (dimethyl glyoxime)
				2, 3, 5	gravimetric (dimethyl glyoxime)

Notes

This Certified Reference Material has been produced and certified 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. However, testing has shown that the above certification is 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. Technical support for this certification will therefore expire in June 2033, 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.