MBH ANALYTICAL LTD

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CERTIFICATE OF ANALYSIS

28X 7186 (batch J)

Certified Reference Material Information

Type:	NICKEL INCONEL 718-TYPE (CAST)
Form and Size:	Disc 40mm Diameter x 15mm Thickness
Manufactured by:	Polycast Ltd
Certified and Supplied by:	MBH Analytical Ltd

Assigned Values

Percentage element by weight

Element	C	Si	S	P	Mn	Cr	Mo	Co
Value [1]	**0.043**	**0.358**	**0.0264**	**0.020**	**0.398**	**16.13**	**3.24**	**0.579**
Uncertainty [2]	0.002	0.015	0.0014	0.002	0.006	0.07	0.05	0.012

Element	Cu	Fe	Nb	Ti	Al	B	Ni	N
Value [1]	**0.190**	**16.51**	**5.75**	**1.04**	**0.70**	**0.0097**	**55.06**	**0.064**
Uncertainty [2]	0.004	0.10	0.04	0.03	0.02	0.0009	0.10	0.002

Definitions

[1] The above 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 19th November 2008

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 - 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

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	Cr	Mo	Co
1	0.0360	0.333	0.022	0.0178	0.384	15.97	3.110	0.553
2	0.0383	0.334	0.0234	0.018	0.386	16.02	3.15	0.560
3	0.0390	0.335	0.0249	0.0185	0.389	16.03	3.151	0.560
4	0.0415	0.340	0.0249	0.0210	0.390	16.03	3.174	0.565
5	0.0421	0.348	0.026	0.0212	0.392	16.08	3.18	0.575
6	0.0429	0.358	0.0267	0.0233	0.395	16.10	3.23	0.576
7	0.044	0.360	0.0271	0.0234	0.396	16.12	3.24	0.582
8	0.0451	0.363	0.0271		0.399	16.13	3.25	0.583
9	0.0459	0.366	0.0282		0.400	16.16	3.265	0.583
10	0.046	0.373	0.0282		0.400	16.17	3.281	0.585
11	0.0466	0.378	0.0287		0.402	16.23	3.297	0.591
12	0.047	0.383	0.0293		0.407	16.26	3.328	0.595
13	0.0482	0.389			0.410	16.28	3.332	0.595
14					0.415	16.30	3.341	0.599
Mean	**0.0433**	**0.358**	**0.0264**	**0.0204**	**0.398**	**16.13**	**3.24**	**0.579**
Std Dev	0.0037	0.019	0.0022	0.0024	0.009	0.10	0.07	0.015
C (95%)	0.0023	0.012	0.0014	0.0022	0.005	0.06	0.04	0.008

Sample	Cu	Fe	Nb	Ti	Al	B	Ni	N
1	0.174	16.28	5.68	0.995	0.670	0.0080	55.02	0.0598
2	0.178	16.28	5.681	1.002	0.672	0.0084	55.02	0.062
3	0.188	16.29	5.69	1.009	0.675	0.0094	55.02	0.0637
4	0.189	16.41	5.703	1.010	0.686	0.0096	55.08	0.0639
5	0.189	16.47	5.716	1.020	0.694	0.0102	55.10	0.064
6	0.190	16.49	5.752	1.040	0.703	0.0103	55.10	0.065
7	0.190	16.52	5.757	1.062	0.718	0.0105		0.0654
8	0.190	16.52	5.759	1.08	0.722	0.0112		0.0657
9	0.192	16.55	5.776	1.080	0.742			0.068
10	0.193	16.62	5.795	1.089	0.749			
11	0.195	16.66	5.800	1.103				
12	0.200	16.70	5.803					
13	0.206	16.79	5.81					
Mean	**0.190**	**16.51**	**5.748**	**1.044**	**0.703**	**0.0097**	**55.06**	**0.0642**
Std Dev	0.008	0.16	0.049	0.039	0.030	0.0011	0.04	0.0023
C (95%)	0.004	0.10	0.029	0.027	0.021	0.0009	0.04	0.0018

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 1385
IncoTest Ltd	Hereford, England	UKAS accreditation 0281
Bodycote Materials Testing	Middlesbrough, England	UKAS accreditation 0239
London & Scandinavian Metallurgical Co	Rotherham, England	UKAS accreditation 1091
Sheffield Assay Office	Sheffield, England	UKAS accreditation 0012
Genitest, Inc	Montreal, Canada	PRI accreditation 123077
Bodycote Materials Testing Inc	Portland, OR, USA	PRI accreditation 118364
Universal Scientific Laboratory Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Institute of Iron & Steel Technology	Shanghai, China	CNAL accreditation 0783
Luo Yang Copper Co	Luo Yang, China	CNAL accreditation 0173
TCR Engineering Services Ltd	Mumbai, India	NABL accreditation 0367
Sargam Metals Pvt Ltd	Chennai, India	NABL accreditation 0025
Shriram Institute for Industrial Research	Delhi, India	NABL accreditation 0045
De Bruyn Spectroscopic Solutions	Johannesburg, South Africa	

Note: to achieve the above accreditation (eg UKAS, PRI, 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	
Carbon	-	-	-	all	combustion (infra-red detection)
Silicon	1, 3, 5, 11	7, 8	-	2, 4, 6, 9, 12	gravimetric (perchloric acid)
				10, 13	photometric (molybdenum blue)
Sulfur	-	-	-	all	combustion (infra-red detection)
Phosphorus	2, 3, 5, 7	-	-	1, 6	photometric (molybdenum blue)
				4	volumetric (alkalimetric)
Manganese	1, 2, 7-9, 11, 14	4, 11	3, 6, 10	5	photometric (periodate)
				12, 13	volumetric (arsenite)
Chromium	1-3, 7, 9, 14	6, 11	10	4, 5, 8, 12, 13	volumetric (FAS)
Molybdenum	3-6, 10	7, 12	2, 8, 13, 14	9, 11	photometric (thiocyanate)
				1	gravimetric
Cobalt	1, 4, 5, 9, 10, 12, 13	3, 7	2, 6, 8, 11, 14		
Copper	1, 6, 7, 10, 11, 13	4, 12	3, 5, 8, 9	2	photometric (BCO)
Iron	1-3, 7, 10, 12	6, 9	4, 5, 10	8, 11, 13	volumetric (dichromate)
Niobium	2, 4-6, 8, 9, 12, 13	3	1	7, 10	photometric (chlorosulfophenol-S)
				11	gravimetric
Titanium	2, 4-7	3	8, 9	1, 10, 11	photometric (DAP)
Aluminium	1, 2, 4, 5, 7, 10	9	3, 6, 8		
Boron	1-4, 6-8		-	5	ICP-MS
Nickel	6	-	-	1, 2, 3	gravimetric (DMGO)
				4	volumetric (DMGO/EDTA)
				5	photometric (DMGO)
Nitrogen	-	-	-	5	photometric (Nessler reagent)
				1-4, 6-9	inert gas fusion (thermal conductivity)

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 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 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 November 2028, 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.