

CERTIFICATE OF ANALYSIS

215X HB4 (batch F)

Certified Reference Material Information

Type: HASTELLOY B-Type (CAST)
Form and Size: Disc 43mm Diameter x 20mm Thickness
Manufactured by: Polycast Limited
Certified and Supplied by: MBH Analytical Limited

Assigned Values

Percentage element by weight

Element	C	Si	S	P	Mn	Cu	Fe
Value ¹	0.079	1.02	0.013	0.036	0.666	(0.024)	7.02
Uncertainty ²	0.002	0.03	0.002	0.002	0.015	-	0.07

Element	Cr	Mo	Co	V	W	Ni	N
Value ¹	0.414	27.59	1.71	0.115	(0.028)	61.21	0.0028
Uncertainty ²	0.012	0.13	0.02	0.005	-	0.11	0.0005

Notes: 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 15th September 2006

C Eveleigh



Method of Preparation

This reference material was produced from commercial alloy, induction melted, with compositional adjustment by the addition of minor and trace elements. It was prepared from one melt cast into a single investment mould.

Sampling

Milled samples for chemical analysis were taken from several positions within the mould. In addition, over 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 - 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, described 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 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: Nickel-base alloys are generally prepared by finishing, 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.

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
1	0.077	0.971	0.0094	0.0323	0.630	0.0171	6.900
2	0.077	1.01	0.0100	0.0324	0.638	0.0176	6.95
3	0.0770	1.011	0.0101	0.0347	0.640	0.0184	6.963
4	0.0772	1.012	0.011	0.0348	0.655	0.0201	6.989
5	0.0778	1.015	0.0126	0.0350	0.656	0.0235	7.001
6	0.0780	1.036	0.0128	0.0351	0.679	0.027	7.018
7	0.0792	1.065	0.014	0.037	0.682	0.027	7.052
8	0.0794		0.0148	0.0375	0.685	0.0326	7.06
9	0.082		0.0150	0.0386	0.687	0.0326	7.128
10	0.0821		0.0152	0.0402	0.687		7.15
11	0.0833		0.0152		0.689		
12			0.0161				
Mean	0.0791	1.017	0.0130	0.0358	0.666	0.024	7.021
Std Dev	0.0023	0.029	0.0024	0.0026	0.023	0.006	0.078
C (95%)	0.0016	0.026	0.0015	0.0018	0.015	0.005	0.056

Sample	Cr	Mo	Co	V	W	Ni	N
1	0.393	27.39	1.650	0.110	0.0172	61.09	0.0020
2	0.400	27.42	1.68	0.111	0.024	61.10	0.0023
3	0.402	27.46	1.695	0.113	0.0244	61.15	0.003
4	0.416	27.48	1.702	0.116	0.0251	61.19	0.003
5	0.417	27.52	1.711	0.119	0.0298	61.26	0.0031
6	0.420	27.55	1.714	0.121	0.0325	61.31	0.0032
7	0.422	27.68	1.714		0.0333	61.38	
8	0.423	27.73	1.72		0.0344		
9	0.434	27.81	1.732				
10		27.86	1.754				
Mean	0.414	27.59	1.707	0.115	0.028	61.21	0.0028
Std Dev	0.013	0.17	0.028	0.004	0.006	0.11	0.0005
C (95%)	0.010	0.12	0.020	0.005	0.005	0.10	0.0005

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
Inco Test Ltd	Hereford, England	UKAS accreditation 0281
Metals Technology Testing Ltd	Sheffield, England	UKAS accreditation 0963
London & Scandinavian Met Co	Rotherham, England	UKAS accreditation 1091
Bodycote Materials Testing	Middlesbrough, England	UKAS accreditation 0239
Special Metals Corp	Huntington, WV, USA	A2LA accreditation 1098
Universal Scientific Laboratory Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Institute of Iron and Steel Technology	Shanghai, China	CNAL accreditation 0783
Luo Yang Copper Co Ltd	Luo Yang, He Nan, China	CNAL accreditation 0173
Sargam Metals Pvt Ltd	Chennai, India	NABL accreditation 0025
TCR Engineering Services Pvt Ltd	Mumbai, India	NABL accreditation 0367
De Bruyn Spectroscopic Solutions Ltd	Johannesburg, South Africa	
Genitest Inc	Montreal, Canada	

Note: to achieve National Accreditation (eg UKAS, A2LA, NATA, CNAL, NABL), 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	-	-	-	3	combustion (volumetric detection)
Silicon	3	-	-	others	combustion (infra-red detection)
				1, 2, 4, 6, 7	gravimetric (perchloric acid)
Sulfur	-	-	-	3	photometric (molybdenum blue)
				5	combustion (volumetric detection)
Phosphorus	4, 5, 7, 8	-	-	others	combustion (infra-red detection)
				1, 2, 9, 10	photometric (molybdenum blue)
Manganese	1, 5-7	3	4, 11	3, 6	volumetric (alkalimetric)
				2, 8, 9	photometric (periodate)
				10	volumetric (arsenite)
Copper	2-4, 6, 7	-	1, 5, 8, 9		
Iron	1, 2, 5, 9, 10	-	3, 7, 8	4, 6	volumetric (dichromate)
Chromium	3-5	2	1, 6, 7, 9	8	volumetric (ferrous ammonium sulfate)
Molybdenum	1-3, 7	8	5	4, 9	photometric (thiocyanate)
				6, 10	gravimetric (8-hydroxy quinoline)
Cobalt	2, 4-7	1	8, 9, 10	3	photometric (5-chloro PADAB)
Vanadium	1, 3, 5	-	2, 4, 6		
Tungsten	1, 3, 4, 6-8	-	-	2	photometric (tin dichloride)
				5	ICP-MS
Nickel	5, 7	4	-	1, 6	photometric (dimethyl glyoxime)
				2, 3	gravimetric (dimethyl glyoxime)
Nitrogen	-	-	-	1-4, 6	inert gas fusion (thermal conductivity)
				5	photometric (Nessler reagent)

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 and the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

This certification is applicable to the whole of the disc.

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 September 2026, 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.