

CERTIFICATE OF ANALYSIS

212X NA4 (batch A)

Certified Reference Material Information

Type: NICKEL/COPPER 'MONEL S' (CHILL CAST)
Form and Size: Disc 40mm Diameter x 13mm Thickness
Manufactured by: Brafe Engineering Limited
Certified and Supplied by: MBH Analytical Limited

Certified Analysis

Percentage element by weight

Element	C	Si	S	P	Mn	Cu	Fe	Cr
Value ¹	0.098	3.83	0.004	0.0053	1.082	29.34	2.26	0.120
Uncertainty ²	0.004	0.05	0.001	0.0005	0.013	0.12	0.04	0.005

Element	Nb	Mo	Co	Ti	Al	Mg	Pb	Ni
Value ¹	(0.51)	0.026	0.046	0.037	0.012	0.0014	0.018	62.8
Uncertainty ²	-	0.003	0.003	0.002	0.002	0.0003	0.002	0.2

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 _____

C Eveleigh

on 13th February 2006



Method of Preparation

This reference material was produced from commercial alloy, induction melted. The melt was cast by sequential transfer of aliquots from the furnace into iron moulds. 2mm has been removed from the working face to minimise any surface effects.

Sampling

Milled samples for chemical analysis were taken from several positions within the batch. 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. One disc was also checked for vertical uniformity using the same method. Multiple measurements were taken from each surface under test.

Using the individual data from each surface, standard deviation values were derived for each element. These values were combined with the 95% half-width confidence intervals ($C_{(95\%)}$) obtained from the wet analysis programme, using the square-root of the summed squares, to derive the final uncertainty values.

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

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: 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	Cr
1	0.0913	3.761	0.0023	0.0045	1.064	29.10	2.20	0.110
2	0.0926	3.791	0.0026	0.0045	1.066	29.24	2.20	0.114
3	0.098	3.793	0.003	0.0047	1.077	29.32	2.237	0.116
4	0.0986	3.795	0.0032	0.0051	1.078	29.34	2.260	0.118
5	0.100	3.801	0.0039	0.0052	1.08	29.35	2.265	0.122
6	0.100	3.801	0.0040	0.0058	1.085	29.37	2.289	0.123
7	0.100	3.835	0.0040	0.0060	1.088	29.39	2.304	0.124
8	0.103	3.84	0.0042	0.0060	1.091	29.40	2.334	0.126
9		3.84	0.0049	0.0061	1.107	29.41		0.130
10		3.916				29.48		
11		3.945						
Mean	0.0979	3.829	0.0036	0.0053	1.082	29.34	2.261	0.120
Std Dev	0.0040	0.056	0.0008	0.0007	0.013	0.11	0.048	0.006
C_(95%)	0.0033	0.038	0.0006	0.0005	0.010	0.08	0.040	0.005

Sample	Nb	Mo	Co	Ti	Al	Mg	Pb	Ni
1	0.493	0.020	0.0402	0.0320	0.0093	0.0010	0.0136	62.47
2	0.496	0.0233	0.0405	0.035	0.010	0.0010	0.0149	62.58
3	0.496	0.0240	0.041	0.0352	0.0104	0.0011	0.017	62.60
4	0.509	0.0240	0.044	0.0354	0.0113	0.0013	0.0187	62.78
5	0.554	0.024	0.0457	0.0359	0.0118	0.0015	0.0187	62.83
6		0.0259	0.0484	0.0386	0.0123	0.0015	0.0190	62.90
7		0.0261	0.0489	0.0397	0.0138	0.0017	0.0209	62.95
8		0.0290	0.0490	0.0398	0.0149	0.0018		62.99
9		0.0301	0.0500	0.041	0.016	0.0021		
10		0.0320	0.0514	0.0416				
Mean	0.510	0.0258	0.0459	0.0374	0.0122	0.0014	0.0175	62.76
Std Dev	0.026	0.0036	0.0042	0.0031	0.0023	0.0004	0.0025	0.19
C_(95%)	0.032	0.0026	0.0030	0.0022	0.0018	0.0003	0.0024	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

ATI AllVac Ltd	Sheffield, England	UKAS accreditation 1385
Bodycote Materials Testing	Middlesbrough, England	UKAS accreditation 0239
IncoTest Ltd	Hereford, England	UKAS accreditation 0281
Laboratory Testing Inc	Hatfield, PA, USA	A2LA accreditation 0117
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
TCR Engineering Services Pvt Ltd	Mumbai, India	NABL accreditation 0367
Sargam Metals Pvt Ltd	Chennai, India	NABL accreditation 0025
Institute of Non-Ferrous Metals	Gliwice, Poland	PCA accreditation AB274
De Bruyn Spectroscopic Solutions	Western Cape, South Africa	
Coleshill Laboratories Ltd	Birmingham, England	

Note: to achieve National Accreditation (eg UKAS, A2LA, NATA, CNAL, PCA, 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
Carbon	-	-	all combustion (infra-red detection)
Silicon	7, 11	-	2-4, 6, 8-10 gravimetric (perchloric acid) 1, 5 photometric (molybdenum blue)
Sulfur	-	-	all combustion (infra-red detection)
Phosphorus	1-3, 6, 7	-	4, 8, 9 photometric (molybdenum blue) 5 volumetric (alkalimetric)
Manganese	3, 4, 6, 9	5, 7, 8	1, 2 photometric (periodate)
Copper	4, 10	2	1, 3, 5, 7, 9 electrogravimetric 6, 8 volumetric (thiosulfate)
Iron	3-7	1, 2	8 volumetric (dichromate)
Chromium	2, 5-7, 9	1, 3, 4, 8	
Niobium	2, 3, 5	4	1 photometric (chlorosulfophenol-S)
Molybdenum	2, 4-7, 10	1, 3, 9	8 photometric (thiocyanate)
Cobalt	1, 4, 5, 8-10	2, 3, 6, 7	
Titanium	4-7	2, 3, 9	1, 8, 10 photometric diantipyryl methane, peroxide)
Aluminium	1, 3, 6, 7	2, 4, 9	5, 8 photometric (chrome azurol S)
Magnesium	2-4, 6, 7	1, 5, 8, 9	
Lead	1-3, 5, 7	4, 6	
Nickel	1, 7	-	2, 8 volumetric (dimethyl glyoxime, EDTA) 5 photometric (dimethyl glyoxime) 3, 4, 6 gravimetric (dimethyl glyoxime)

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 February 2026, although we reserve the right to make changes as issue revisions, in the intervening period.

This sample is also available in the form of chippings.

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.