MBH ANALYTICAL LTD

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CERTIFICATE OF ANALYSIS

215X 10276 (batch A)

Certified Reference Material Information

Type:	NICKEL HASTELLOY C276 (WROUGHT)
Form and Size:	Disc ~38mm diameter
Manufactured by:	Deutsche Nickel GmbH
Certified and Supplied by:	MBH Analytical Ltd

Assigned Values

Percentage element by weight

Element	C	Si	S	P	Mn	Cu	Cr	Fe	Mo	Co
Value [1]	**0.008**	**0.029**	**(0.001)**	**0.0027**	**0.498**	**0.0423**	**15.56**	**5.79**	**15.96**	**0.182**
Uncertainty [2]	0.001	0.002	-	0.0002	0.007	0.0012	0.05	0.03	0.09	0.002

Element	Ti	Al	Nb	W	V	Zr	Mg	Ni	N
Value [1]	**0.0186**	**0.203**	**0.031**	**3.59**	**0.196**	**0.009**	**0.0090**	**57.81**	**0.0099**
Uncertainty [2]	0.0010	0.003	0.002	0.02	0.002	0.001	0.0003	0.06	0.0010

Note: values given in parentheses are not certified - they are provided for information only.

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 3rd September 2015

MBH ANALYTICAL LIMITED _____

C Eveleigh

Method of Preparation

This reference material was produced from commercial barstock to UNS N010276, hot finished and annealed. The discs are the product of one length of bar.

Sampling

Samples for chemical analysis were taken from various positions within the bar. 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	Cr	Fe	Mo	Co
1	0.0044	0.0246	0.0005	0.0020	0.478	0.0390	15.46	5.761	15.82	0.178
2	0.0049	0.0263	0.0006	0.0025	0.483	0.0407	15.48	5.766	15.85	0.178
3	0.0049	0.0278	0.0007	0.0025	0.491	0.0411	15.49	5.770	15.85	0.178
4	0.0070	0.0278	0.0008	0.0026	0.492	0.0415	15.50	5.774	15.90	0.180
5	0.0072	0.0285	0.0009	0.0026	0.493	0.0418	15.56	5.780	15.90	0.180
6	0.0076	0.0290	0.0010	0.0026	0.493	0.0421	15.59	5.784	15.90	0.181
7	0.0081	0.0300	0.0012	0.0028	0.496	0.0425	15.59	5.788	15.94	0.182
8	0.0091	0.0304	0.0013	0.0029	0.498	0.0428	15.60	5.819	15.96	0.183
9	0.0099	0.0307	0.0013	0.0030	0.499	0.0429	15.61	5.832	15.99	0.183
10	0.0100	0.0322	0.0015	0.0030	0.502	0.0434	15.62		16.03	0.183
11	0.0103	0.0332	0.0015	0.0031	0.508	0.0437	15.62		16.05	0.184
12	0.0110				0.509	0.0438	15.64		16.06	0.185
13					0.515	0.0450			16.09	0.187
14					0.521				16.13	
Mean	**0.0079**	**0.0291**	**0.0010**	**0.0027**	**0.498**	**0.0423**	**15.56**	**5.785**	**15.96**	**0.182**
Std Dev	0.0023	0.0025	0.0004	0.0003	0.012	0.0016	0.06	0.023	0.10	0.003
C (95%)	0.0014	0.0017	0.0002	0.0002	0.007	0.0009	0.04	0.018	0.06	0.002

Sample	Ti	Al	Nb	W	V	Zr	Mg	Ni	N
1	0.0168	0.197	0.0265	3.554	0.190	0.0075	0.0081	57.73	0.0082
2	0.0169	0.199	0.0275	3.567	0.191	0.0079	0.0086	57.77	0.0082
3	0.0172	0.199	0.0275	3.575	0.194	0.0080	0.0089	57.79	0.0083
4	0.0175	0.200	0.0295	3.579	0.195	0.0084	0.0090	57.79	0.0092
5	0.0185	0.202	0.0298	3.582	0.196	0.0084	0.0091	57.80	0.0098
6	0.0187	0.204	0.0317	3.585	0.196	0.0085	0.0092	57.80	0.0100
7	0.0188	0.205	0.0318	3.591	0.196	0.0087	0.0092	57.82	0.0105
8	0.0193	0.205	0.0330	3.593	0.197	0.0095	0.0093	57.83	0.0109
9	0.0195	0.206	0.0332	3.598	0.198	0.0097	0.0094	57.84	0.0119
10	0.0208	0.211	0.0337	3.600	0.200	0.0115	0.0096	57.88	0.0120
11	0.0211		0.0342	3.619	0.201				
12			0.0364		0.202				
Mean	**0.0186**	**0.203**	**0.0312**	**3.586**	**0.196**	**0.0088**	**0.0090**	**57.81**	**0.0099**
Std Dev	0.0015	0.004	0.0031	0.018	0.004	0.0012	0.0004	0.04	0.0014
C (95%)	0.0010	0.003	0.0020	0.012	0.002	0.0009	0.0003	0.03	0.0010

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
Sheffield Assay Office	Sheffield, England	UKAS accreditation 0012
Birmingham Assay Office	Birmingham, England	UKAS accreditation 0667
Metals Technology (Testing) Ltd	Sheffield, England	UKAS accreditation 0963
Genitest, Inc	Montreal, Canada	PRI accreditation 123077
Shanghai Jinyi Test Technology Co	Shanghai, China	CNAL accreditation 0783
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS accreditation 1461
Bureau Veritas CPS Pvt Ltd	Chennai, India	NABL accreditation 0025
TCR Engineering Services Ltd	Mumbai, India	NABL accreditation 0367
Raghavendra Spectrometallurgical Lab.	Bangalore, India	NABL accreditation 0371
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA accreditation AB554
Tec-Eurolab	Campogalliano, Italy	ACCREDIA accreditation 52
PT Geoservices Ltd	Cikarang, Indonesia	
AMG Superalloys UK Ltd	Rotherham, England	
Coleshill Laboratories Ltd	Birmingham, England	
Analyticka Laborator Lithea sro	Brno, Czech Republic	

Note: to achieve the above accreditation (eg UKAS, etc), test houses are required to 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 (IR or volumetric detection)
Silicon	3, 7-11	-	1, 5	gravimetric (perchloric acid)
			2, 4, 6	photometric (molybdenum blue)
Sulfur	11	-	1-10	combustion (IR or volumetric detection)
Phosphorus	1-3, 6-8, 10, 11	-	4, 5	volumetric (alkalimetric)
			9	photometric (molybdenum blue)
Manganese	1, 2, 4, 6, 8-10, 12-14	7	3, 11	photometric (periodate)
			5	volumetric (arsenite)
Copper	1-4, 6, 8-11	12, 13	5, 7	photometric (BCO)
Chromium	1, 4, 8, 10-12	6	2, 3, 5, 7, 9	volumetric (ferrous ammonium sulfate)
Iron	2, 4, 7	3, 5	1, 6, 8, 9	volumetric (dichromate)
Molybdenum	1, 2, 6-8, 11-14	5	3, 4	gravimetric
			9, 10	photometric (thiocyanate)
Cobalt	2-5, 7, 9-13	8	1	photometric (2β naphthol)
			6	volumetric (iodine)
Titanium	3-7, 10, 11	2, 8	1, 9	photometric (DAP)
Aluminium	1, 3, 5-7, 9, 10	2, 4	8	photometric (chrome azurol S)
Niobium	1, 3, 4, 6-12	-	2	ICP-MS
			5	photometric (chlorosulfophenol)
Tungsten	1, 3-5, 8-11	-	2, 7	photometric (thiocyanate)
			6	ICP-MS
Vanadium	1-8, 10-12	9		
Zirconium	1, 3-6, 8-11	7	2	XRF
Magnesium	1, 2, 4-9	3, 10		
Nickel	1, 5, 6, 8	3	2, 4, 10	gravimetric (dimethyl glyoxime)
			7, 9	volumetric (EDTA/DMGO)
Nitrogen	-	-	1, 8, 9	volumetric (hydrochloric acid)
			2-6, 10	inert gas fusion (thermal conductivity)
			7	photometric (Nessler's reagent)

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).

This certification is applicable to the whole of the disc. However, in accordance with normal practice for emission spectrometry, it is appropriate to avoid usage of the central portion of the disc, ~8 mm diameter.

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. This certification will therefore expire in September 2035, 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.