MBH ANALYTICAL LTD

HOLLAND HOUSE • QUEENS ROAD • BARNET • EN5 4DJ • ENGLAND • TEL: +44 (0)20 8441 2024 • FAX: +44 (0)20 8449 0810

email: info@mbh.co.uk web: www.mbh.co.uk

CERTIFICATE OF ANALYSIS

13X NSC3 (batch AA)

Certified Reference Material Information

Type: NITROGEN STAINLESS STEEL (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	Mn	Ni	Cr
Value [1]	**0.868**	**1.51**	**0.0295**	**8.43**	**5.00**	**22.32**
Uncertainty [2]	0.011	0.04	0.0009	0.05	0.04	0.06

Element	Mo	Al	Cu	Nb	V	N
Value [1]	**0.057**	**0.051**	**0.292**	**2.45**	**0.098**	**0.480**
Uncertainty [2]	0.003	0.002	0.005	0.03	0.002	0.010

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 7th January 2019

C Eveleigh

Method of Preparation

This reference material was produced from commercial-purity metals, with the minor and trace elements added as pure elements, binaries and master alloys. The discs are the product of one melt poured into 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

Milled samples for chemical analysis were taken from several positions within the batch. In addition, at least 15% of all discs were selected for homogeneity checking.

Homogeneity

Samples representative of the batch were checked for uniformity using an optical emission spectrometer.

For all accepted material, through-batch variation values were derived for each element as an indicator of any minor compositional variation (as determined for the specific sample size and other limitations of 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 ISO 17025, 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.

Of the individual results herein, some have traceability (to the mole) via primary analytical methods. Some are traceable to substances of known stoichiometry. Most have traceability via commercial solutions. Furthermore, some results have additional 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: Steels are generally prepared by linishing, grinding, turning or milling. 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 optical emission spectroscopy, 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	Mn	Ni	Cr
1	0.8440	1.443	0.0275	8.344	4.908	22.22
2	0.8459	1.466	0.0278	8.363	4.920	22.27
3	0.8512	1.467	0.0281	8.366	4.930	22.27
4	0.8560	1.485	0.0289	8.399	4.951	22.27
5	0.8730	1.501	0.0289	8.412	4.953	22.30
6	0.8732	1.517	0.0290	8.416	4.977	22.30
7	0.8783	1.521	0.0291	8.418	4.980	22.33
8	0.8798	1.568	0.0296	8.422	4.980	22.34
9	0.8820	1.570	0.0298	8.440	4.997	22.38
10	0.8827	1.583	0.0298	8.448	5.013	22.39
11	0.8840		0.0302	8.485	5.016	22.42
12			0.0302	8.495	5.053	
13			0.0304	8.519	5.062	
14			0.0304		5.066	
15			0.0313		5.100	
16			0.0315		5.112	
Mean	**0.8682**	**1.512**	**0.0295**	**8.425**	**5.001**	**22.32**
Std Dev	0.0157	0.049	0.0012	0.052	0.063	0.06
C (95%)	0.0105	0.035	0.0006	0.032	0.034	0.04

Sample	Mo	Al	Cu	Nb	V	N
1	0.0518	0.0458	0.2802	2.380	0.0934	0.4633
2	0.0536	0.0465	0.2805	2.381	0.0955	0.4658
3	0.0543	0.0487	0.2812	2.413	0.0970	0.4690
4	0.0550	0.0491	0.2853	2.427	0.0970	0.4760
5	0.0561	0.0504	0.2865	2.430	0.0987	0.4793
6	0.0563	0.0508	0.2865	2.437	0.0988	0.4840
7	0.0576	0.0509	0.2870	2.465	0.0990	0.4887
8	0.0588	0.0510	0.2933	2.472	0.0998	0.4940
9	0.0592	0.0533	0.2970	2.474	0.1026	0.4983
10	0.0606	0.0540	0.2987	2.488	0.1029	
11	0.0623	0.0552	0.2994	2.517		
12	0.0624	0.0558	0.3000	2.522		
13			0.3040			
14			0.3063			
Mean	**0.0573**	**0.0510**	**0.2919**	**2.451**	**0.0984**	**0.4798**
Std Dev	0.0034	0.0032	0.0090	0.047	0.0029	0.0125
C (95%)	0.0022	0.0020	0.0052	0.030	0.0021	0.0096

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 Analytical Services	Sheffield, England	UKAS accreditation 0012
Metals Technology (Testing) ltd	Sheffield, England	UKAS accreditation 0963
Anchorcert Analytical	Birmingham, England	UKAS accreditation 0667
Laboratory Testing, Inc	Hatfield, PA, USA	A2LA accreditation 0117
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Genitest, Inc	Montreal, Canada	PJ accreditation L17-153
Shanghai Jinyi Test Tech Co	Shanghai, China	CNAS accreditation 0041
Luo Yang Copper	Luo Yng, He Nan, China	CNAL accreditation 0173
Raghavendra SpectroMet Laboratory	Bangalore, India	NABL accreditation 0371
TCR Engineering Services Ltd	Mumbai, India	NABL accreditation 0367
Gesra Labs India Pvt	Chennai, India	NABL accreditation 6238
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA accreditation AB554
Tec-Eurolab	Campogalliano, Italy	ACCREDIA accreditation 52
TUV Nord Czech	Brno, Czech Republic	CAI accreditation L1060
INCDMNR-IMNR	Pantelimon, Romania	
Mineral & Metallurgical Laboratories	Bangalore, India	
AMG Superalloys UK Ltd	Rotherham, England	
Analyticka Laborator Lithea sro	Brno, Czech Republic	

Note: to achieve the above accreditation (UKAS, etc), 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	1, 4	-	2, 3, 5, 7, 10	gravimetric (perchloric acid)
			6, 8, 9	photometric (molybdenum blue)
Sulfur	12. 13	-	1-11, 14-16	combustion (IR or volumetric detection)
Manganese	2-4, 6-8,	1, 9, 11	5, 10, 13	volumetric (arsenite, FAS)
			12	photometric (periodate)
Nickel	4, 5, 7, 9-15	16	1, 2, 6	gravimetric (dimethyl glyoxime)
			3, 8	volumetric (dimethyl glyoxime, EDTA)
Chromium	1, 6, 9, 10	11	2-5, 7, 8	volumetric (ferrous ammonium sulfate)
Molybdenum	1-6, 8, 9, 11	7, 10	12	photometric (thiocyanate)
Aluminium	1, 3-6, 10-12	7, 8	2	photometric (chrome azurol S)
			9	volumetric (EDTA)
Copper	2-6, 8, 10-12, 14	1, 9, 13	7	photometric (BCO)
Niobium	2-4, 6-9, 11	1, 5	10	gravimetric (n-benzoyl, n-PH)
			12	photometric (chlorosulfophenol)
Vanadium	2, 4, 6, 8-10	1, 3	5, ,7	volumetric (ferrous ammonium sulfate)
Nitrogen	-	-	1-3, 5-9	inert gas fusion (thermal conductivity)
			4	photometric (Nessler reagent)

Notes

This Certified Reference Material has been produced and certified, wherever possible, in accordance with the requirements of ISO Guide 17034 and the associated guides, taking into account the requirements of the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

The unidirectional solidification effects associated with this method of chill casting, have led to the formation of inhomogeneous segregates in the rear portion of the disc. The above certification is therefore only applicable from the front face of the disc. Material to the rear of the disc, to a depth of ~3 mm, 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 January 2039, 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.