MBH ANALYTICAL LTD

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CERTIFICATE OF ANALYSIS

12X 349 (batch D)

Certified Reference Material Information

Type:	LOW-ALLOY STEEL (WROUGHT)
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	P	Mn	Ni	Cr	Mo
Value [1]	**0.194**	**0.201**	**0.0232**	**0.0162**	**0.498**	**0.289**	**0.268**	**0.123**
Uncertainty [2]	0.004	0.005	0.0010	0.0004	0.007	0.006	0.005	0.004

Element	Cu	Co	V	W	Al	Ti	Sn	As
Value [1]	**0.106**	**0.021**	**0.0172**	**0.049**	**0.149**	**0.101**	**0.153**	**0.0096**
Uncertainty [2]	0.002	0.001	0.0009	0.003	0.004	0.003	0.002	0.0007

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:

on 24th April 2016

MBH ANALYTICAL LIMITED _____

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Method of Preparation

This reference material was produced from commercial-purity metals and master alloys. The discs are the product of one melt, cast into 70mm diameter billets and hot worked into bars of ~42mm diameter.

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. 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 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: 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	P	Mn	Ni	Cr	Mo
1	0.1897	0.1940	0.0215	0.0154	0.4820	0.2780	0.2624	0.1203
2	0.1900	0.1974	0.0218	0.0161	0.4831	0.2800	0.2647	0.1207
3	0.1920	0.1992	0.0222	0.0161	0.4912	0.2819	0.2650	0.1208
4	0.1920	0.1997	0.0224	0.0161	0.4920	0.2830	0.2655	0.1209
5	0.1922	0.2002	0.0228	0.0161	0.4971	0.2835	0.2670	0.1211
6	0.1925	0.2003	0.0230	0.0162	0.5000	0.2843	0.2687	0.1221
7	0.1927	0.2010	0.0230	0.0165	0.5010	0.2856	0.2700	0.1230
8	0.1930	0.2020	0.0236	0.0167	0.5010	0.2933	0.2700	0.1245
9	0.1983	0.2055	0.0236	0.0169	0.5011	0.2945	0.2709	0.1250
10	0.2000	0.2060	0.0237		0.5017	0.2951	0.2718	0.1250
11	0.2005	0.2075	0.0240		0.5050	0.2952	0.2760	0.1252
12			0.0245		0.5066	0.2953		0.1253
13			0.0245		0.5086	0.2980		0.1260
14			0.0248			0.2997		
Mean	**0.1939**	**0.2012**	**0.0232**	**0.0162**	**0.4977**	**0.2891**	**0.2684**	**0.1231**
Std Dev	0.0038	0.0040	0.0010	0.0004	0.0084	0.0074	0.0039	0.0022
C (95%)	0.0026	0.0027	0.0006	0.0003	0.0051	0.0043	0.0026	0.0013

Sample	Cu	Co	V	W	Al	Ti	Sn	As
1	0.1001	0.0194	0.0164	0.0481	0.1462	0.0981	0.1500	0.0082
2	0.1010	0.0199	0.0166	0.0486	0.1477	0.0984	0.1503	0.0089
3	0.1020	0.0199	0.0167	0.0487	0.1480	0.0991	0.1507	0.0089
4	0.1020	0.0201	0.0169	0.0487	0.1481	0.0991	0.1513	0.0090
5	0.1033	0.0202	0.0170	0.0488	0.1483	0.0998	0.1516	0.0090
6	0.1059	0.0204	0.0172	0.0494	0.1490	0.1010	0.1519	0.0093
7	0.1063	0.0208	0.0172	0.0499	0.1501	0.1010	0.1522	0.0096
8	0.1073	0.0213	0.0173	0.0502	0.1504	0.1016	0.1523	0.0100
9	0.1080	0.0220	0.0174	0.0503	0.1510	0.1021	0.1528	0.0103
10	0.1085	0.0221	0.0174	0.0504	0.1520	0.1030	0.1530	0.0112
11	0.1090	0.0222	0.0175			0.1049	0.1550	0.0114
12	0.1096		0.0181			0.1060	0.1560	
13	0.1101		0.0183				0.1563	
14	0.1103							
15	0.1113							
Mean	**0.1063**	**0.0208**	**0.0172**	**0.0493**	**0.1491**	**0.1012**	**0.1526**	**0.0096**
Std Dev	0.0037	0.0010	0.0005	0.0008	0.0018	0.0025	0.0020	0.0010
C (95%)	0.0020	0.0007	0.0003	0.0006	0.0013	0.0016	0.0012	0.0007

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, UK	UKAS accreditation	0239
Sheffield Analytical Services	Sheffield, UK	UKAS accreditation	0012
Metals Technology (Testing) Ltd.	Sheffield, UK	UKAS accreditation	0963
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation	0492
Shanghai JinYi Test Technology Co. Ltd	Shanghai, China	CNAL accreditation	0783
Bureau Veritas CPS PVT. Ltd.	Chennai, India	NABL accreditation	0025
TCR Engineering Services PVT. Ltd.	Mumbai, India	NABL accreditation	0367
Raghavendra Spectro Metallurgical Laboratory	Bangalore, India	NABL accreditation	0371
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS accreditation	1461
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA accreditation	AB554
TEC Eurolab SRL	Modena, Italy	ACCREDIA accreditation	52
AMG Superalloys UK Ltd	Rotherham, UK		
Analyticka Laborator Lithea sro	Brno, Czech Republic		
Colonial Metal Co. Laboratory	Columbia, USA		
Coleshill Laboratories Ltd	Coleshill, UK		

Note: to achieve the above accreditation (UKAS, 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	FAAS	OTHER	
Carbon	-	-	all	combustion (infra-red detection)
Silicon	1-3, 5, 6, 11	-	4, 9	gravimetric (perchloric acid)
			7, 8, 10	photometric (molybdenum blue)
Sulfur	4	-	1-3, 5-14	combustion (infra-red detection)
Phosphorus	2-7	-	1	volumetric (alkalimetric)
			8, 9	photometric (molybdenum blue)
Manganese	1, 4, 6, 8-10, 12, 13	2, 3	5, 11	photometric (periodate)
			7	volumetric (ferrous ammonium sulfate)
Nickel	1, 4, 5, 7-10, 12, 14	3, 6, 11	2, 13	photometric (dimethyl glyoxime)
Chromium	1, 4, 6, 9-11	2, 7, 8	3	photometric (diphenyl carbazide)
			5	volumetric (ferrous ammonium
Molybdenum	1-4, 6, 8-12	5	7, 13	photometric (thiocyanate)
Copper	2, 3, 5, 7, 9, 10, 12-15	1, 6, 8	4, 11	photometric (BCO)
Cobalt	1, 3-10	2, 11		
Vanadium	1, 3-7, 9-11, 13	2, 12	8	volumetric (ferrous ammonium sulfate)
Tungsten	1-4, 6, 7, 9, 10	5	8	photometric (thiocyanate)
Aluminium	4-8	1-3	9, 10	photometric (chrome azurol S)
Titanium	3, 5, 7-12	2, 4	1, 6	photometric (diantipyryl methane)
Tin	2-7, 9, 11-13	1, 8, 10		
Arsenic	1, 2, 4-10	3, 11		

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 centre 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. Technical support for this certification will therefore expire in April 2036, 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, for the assessment of ‘wet’ analytical techniques.

The manufacture, analysis and certification of this product were supervised by L Maxim, Technical Director, MBH Analytical Ltd.

The material to which this certificate of analysis refers is supplied subject to our general conditions of sale.