

CERTIFICATE OF ANALYSIS

11X HPC2 (batch L)

Certified Reference Material Information

Type: HIGH-PHOSPHORUS CAST IRON (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	P	Mn	Ni
Value ¹	3.18	2.20	0.0418	1.51	1.005	0.388
Uncertainty ²	0.03	0.02	0.0016	0.02	0.006	0.007

Element	Cr	Mo	Cu	Ti	Nb	V
Value ¹	1.509	0.0354	0.0460	0.0502	0.0354	0.0350
Uncertainty ²	0.010	0.0011	0.0012	0.0013	0.0009	0.0006

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 _____
L Maxim

on 22nd April 2016

Method of Preparation

This reference material was produced from commercial-purity metals, 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 random positions within the casting sequence. In addition, 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 - 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 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. 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: Cast irons are generally prepared by finishing, milling or by machining on a lathe. 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.

Important note: For OES, this sample may require up to 120 seconds pre-spark before each analysis.

Analytical Data

Percentage element by weight

Sample	C	Si	S	P	Mn	Ni
1	3.158	2.1600	0.0389	1.477	0.9889	0.3712
2	3.160	2.1713	0.0396	1.490	0.9948	0.3812
3	3.163	2.1866	0.0401	1.495	0.9985	0.3826
4	3.165	2.1880	0.0402	1.495	1.0000	0.3855
5	3.170	2.1912	0.0402	1.498	1.0000	0.3861
6	3.177	2.2016	0.0410	1.507	1.0010	0.3867
7	3.178	2.2140	0.0418	1.507	1.0034	0.3909
8	3.185	2.2180	0.0421	1.512	1.0051	0.3963
9	3.195	2.2240	0.0435	1.519	1.0100	0.3973
10	3.202	2.2490	0.0443	1.520	1.0105	0.3995
11	3.204		0.0446	1.520	1.0124	
12			0.0450	1.533	1.0179	
13				1.538	1.0197	
Mean	3.178	2.2004	0.0418	1.509	1.0048	0.3877
Std Dev	0.017	0.0265	0.0021	0.018	0.0090	0.0086
C (95%)	0.011	0.0190	0.0013	0.011	0.0054	0.0062

Sample	Cr	Mo	Cu	Ti	Nb	V
1	1.4925	0.0342	0.0448	0.0468	0.0347	0.0337
2	1.4975	0.0344	0.0452	0.0485	0.0350	0.0337
3	1.5000	0.0347	0.0452	0.0486	0.0350	0.0341
4	1.5012	0.0350	0.0454	0.0490	0.0351	0.0345
5	1.5030	0.0350	0.0455	0.0495	0.0352	0.0349
6	1.5090	0.0351	0.0457	0.0498	0.0353	0.0351
7	1.5120	0.0351	0.0458	0.0498	0.0355	0.0352
8	1.5195	0.0352	0.0464	0.0500	0.0355	0.0353
9	1.5206	0.0354	0.0464	0.0504	0.0357	0.0353
10	1.5210	0.0355	0.0466	0.0511	0.0357	0.0354
11	1.5250	0.0357	0.0471	0.0516	0.0365	0.0354
12		0.0360	0.0477	0.0539		0.0355
13		0.0371		0.0541		0.0355
14		0.0371				0.0357
Mean	1.5092	0.0354	0.0460	0.0502	0.0354	0.0350
Std Dev	0.0111	0.0009	0.0009	0.0021	0.0005	0.0007
C (95%)	0.0075	0.0005	0.0006	0.0013	0.0003	0.0004

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
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	Chennai, India	NABL accreditation	0025
TCR Engineering Services PVT. Ltd.	Mumbai, India	NABL accreditation	0367
Raghavendra Spectro Metallurgical Laboratory	Bangalore, India	NABL accreditation	0371
Laboratory Testing	Hatfield, PA, USA	A2LA accreditation	0117
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		
Mineral and Metallurgical Laboratories	Bangalore, India		
Coleshill Laboratories Limited	Coleshill, UK		

Note: to achieve National Accreditation (eg 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	3-5, 10	-	1, 8	photometric (molybdenum blue)
			2, 6, 7, 9	gravimetric (perchloric acid)
Sulfur	9	-	1-8, 10-12	combustion (volumetric or IR detection)
Phosphorus	2, 4-7, 9, 10, 13	-	1, 12	volumetric (alkalimetric)
			3, 8, 11	photometric (molybdenum blue)
Manganese	1-3, 7, 10, 11, 13	5, 9	4	volumetric (arsenite)
			6, 8, 12	photometric (periodate)
Nickel	1, 3, 4, 6-10	2, 5		
Chromium	1, 2, 5, 8, 11	3, 9	4, 6, 7	volumetric (ferrous ammonium sulfate)
			10	photometric (diphenyl carbazide)
Molybdenum	2, 4-7, 10-14	1, 3	8, 9	photometric (thiocyanate)
Copper	2, 3, 5, 7-11	1, 12	4	volumetric (thiosulfate)
			6	photometric (BCO)
Titanium	2-4, 7-9, 11, 12	1, 5, 13	6	photometric (diantipyryl methane)
			10	photometric (hydrogen peroxide)
Niobium	1-5, 8-11	-	6	photometric (chlorosulfophenol)
			7	gravimetric
Vanadium	1, 4, 5, 8-11, 13, 14	3, 6, 12	2, 7	volumetric (ferrous ammonium sulfate)

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).

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 ~3mm, is not certified.

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. 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.

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.