

CERTIFICATE OF ANALYSIS

11X 15309 (batch S)

Certified Reference Material Information

Type: CAST IRON WITH CHROMIUM (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	Cr
Value ¹	3.05	1.398	0.086	0.040	1.506	0.919	23.26
Uncertainty ²	0.03	0.015	0.004	0.002	0.009	0.011	0.04

Element	Co	Cu	Mo	V	W	Nb	Ti
Value ¹	0.032	0.505	0.249	0.056	0.015	0.0192	0.0156
Uncertainty ²	0.001	0.007	0.003	0.002	0.001	0.0010	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 _____

on 18th April 2016

L Maxim



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 a sequence of 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

Samples for chemical analysis were taken from various positions throughout the casting process. At least 15% of the 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 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: Cast irons are generally prepared by finishing, 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.

The recommended sample size is at least five replicate analyses. 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
1	2.985	1.370	0.0771	0.0381	1.484	0.8922	23.19
2	3.002	1.378	0.0802	0.0386	1.485	0.8989	23.20
3	3.026	1.382	0.0837	0.0389	1.490	0.8997	23.21
4	3.032	1.383	0.0851	0.0395	1.491	0.9100	23.22
5	3.039	1.391	0.0854	0.0397	1.498	0.9104	23.25
6	3.053	1.399	0.0862	0.0404	1.503	0.9140	23.26
7	3.060	1.406	0.0876	0.0405	1.504	0.9145	23.27
8	3.084	1.407	0.0902	0.0410	1.511	0.9217	23.27
9	3.085	1.418	0.0909	0.0420	1.513	0.9224	23.28
10	3.105	1.424	0.0937	0.0422	1.513	0.9240	23.29
11		1.424			1.520	0.9284	23.33
12					1.521	0.9385	23.34
13					1.522	0.9420	
14					1.529	0.9450	
Mean	3.047	1.398	0.0860	0.0401	1.506	0.9187	23.26
Std Dev	0.038	0.019	0.0050	0.0014	0.015	0.0162	0.05
C (95%)	0.027	0.013	0.0036	0.0010	0.008	0.0094	0.03

Sample	Co	Cu	Mo	V	W	Nb	Ti
1	0.0288	0.4901	0.2400	0.0519	0.0143	0.0172	0.0144
2	0.0296	0.4920	0.2440	0.0528	0.0145	0.0174	0.0149
3	0.0307	0.4925	0.2440	0.0529	0.0148	0.0182	0.0151
4	0.0308	0.4979	0.2443	0.0534	0.0149	0.0186	0.0151
5	0.0315	0.5000	0.2460	0.0541	0.0153	0.0187	0.0151
6	0.0317	0.5059	0.2480	0.0552	0.0153	0.0193	0.0153
7	0.0323	0.5067	0.2502	0.0557	0.0154	0.0195	0.0154
8	0.0323	0.5092	0.2506	0.0559	0.0155	0.0204	0.0156
9	0.0325	0.5120	0.2510	0.0566	0.0157	0.0207	0.0158
10	0.0329	0.5130	0.2511	0.0573	0.0160	0.0207	0.0160
11	0.0330	0.5130	0.2520	0.0579	0.0165	0.0208	0.0162
12	0.0331	0.5136	0.2560	0.0586			0.0166
13	0.0349	0.5220	0.2561	0.0591			0.0170
14	0.0353			0.0610			
15	0.0354			0.0613			
Mean	0.0323	0.5052	0.2487	0.0562	0.0153	0.0192	0.0156
Std Dev	0.0019	0.0099	0.0049	0.0030	0.0007	0.0013	0.0007
C (95%)	0.0011	0.0060	0.0030	0.0017	0.0005	0.0009	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, Australia	NATA accreditation 0492
Shanghai JinYi Test Technology Co. Ltd	Shanghai, China	CNAL accreditation 0783
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS accreditation 1461
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
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA accreditation AB554
Laboratory Testing	Hatfield, USA	A2LA accreditation 0117
TEC Eurolab SRL	Modena, Italy	ACCREDIA accreditation 52
Mineral and Metallurgical Laboratories	Bangalore, India	
AMG Superalloys UK Ltd	Rotherham, UK	
Analyticka Laborator Lithea sro	Brno, Czech Republic	
Coleshill Laboratories Limited	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	2, 3, 6, 9, 11	-	1, 7 photometric (molybdenum blue)
			4, 5, 8, 10 gravimetric (perchloric acid)
Sulfur	2, 5	-	1, 3, 4, 6-10 combustion (infra-red detection)
Phosphorus	1, 4, 5, 8, 10	-	2, 6, 7 photometric (molybdenum blue)
			3, 9 volumetric (alkalimetric)
Manganese	1, 4-8, 11	2, 12	3, 13, 14 photometric (periodate)
			9, 10 volumetric (arsenite, FAS)
Nickel	2, 3, 5, 8, 9, 11-12	4, 7, 13	1, 10, 14 photometric (dimethyl glyoxime)
			6 gravimetric (dimethyl glyoxime)
Chromium	2, 5, 8, 9	7, 10	1 photometric (diphenyl carbazide)
			3, 4, 6, 11, 12 volumetric (ferrous ammonium sulfate)
Cobalt	1, 3, 4, 6, 8-11, 13, 15	2, 12, 14	5 photometric (2 β-naphthol)
			7 gravimetric (oxide)
Copper	1, 2, 4, 6-8, 12, 13	3, 5, 9	10 volumetric (thiosulfate)
			11 photometric (BCO)
Molybdenum	2, 4-8, 12, 13	1, 9, 10	3, 11 photometric (thiocyanate)
Vanadium	1-3, 7, 9-14	4-6	8 volumetric (ferrous ammonium sulfate)
			15 volumetric (peroxi-di-sulphate)
Tungsten	1-6, 8, 10, 11	9	7 photometric (thiocyanate)
Niobium	1-5, 7-10	6	11 photometric (chlorosulfophenol)
Titanium	1, 3, 4, 7-9, 13	2, 11, 12	5, 10 photometric (diantipryl methane)
			6 photometric (hydrogen peroxide)

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 minor segregation to the rear of the disc. The above certification is therefore only applicable from the front face of the disc, to a depth of 12mm. The remainder, of ~3mm thickness, 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 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.