

CERTIFICATE OF ANALYSIS

11X C6 (batch U)

Certified Reference Material Information

Type: CAST IRON (CHILL CAST)
Form and Size: Disc 40mm Diameter x ~17mm Thickness
Produced by: Polycast Ltd
Certified and supplied by: MBH Analytical Limited

Certified Analysis

Percentage element by weight

Element	C	Si	S	P	Mn	Ni	Cr	Mo	Cu
Value ¹	3.60	0.464	0.034	0.057	0.934	0.123	0.493	1.54	0.87
Uncertainty ²	0.03	0.015	0.002	0.002	0.011	0.004	0.010	0.02	0.02

Element	Sn	Al	Ti	V	Nb	Co	W	Pb	As
Value ¹	0.061	(0.014)	0.141	0.0622	0.008	0.086	0.016	(0.0007)	0.052
Uncertainty ²	0.003	-	0.005	0.0017	0.001	0.005	0.002	-	0.003

Element	Zr	Sb	Bi	Se	Te	Zn	B	N
Value ¹	0.0161	0.0024	0.022	0.0179	0.0165	0.029	0.0052	(0.0034)
Uncertainty ²	0.0013	0.0004	0.004	0.0007	0.0015	0.002	0.0002	-

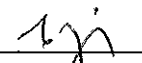
Note: values given in parentheses are not certified - they are provided for information only.

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


C Eveleigh

on 24th September 2003



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. Metal was 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, 10% 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, and averaged. The overall mean value for the material was then calculated.

For each of the surfaces checked, the differences between the averaged result and the overall mean value were evaluated to ensure that the homogeneity of the material satisfied the acceptance criteria defined in ISO guide 30 - 1992.

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 - 2000, using documented standard reference methods and validated by appropriate reference materials.

The individual values listed overpage are the average of each analyst's results.

Traceability

Most of the analytical work performed to assess this material has been carried out by laboratories with proven competence, as indicated by their accreditation to a national authority. 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.

Uncertainties

The uncertainty values are generated from the 95% half-width confidence interval $C_{(95\%)}$, which is derived from the wet analysis results, in accordance with the following 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.

Separate standard deviation values were also derived for each element, from the homogeneity testing described above. These values were combined with the 95% half-width confidence intervals ($C_{(95\%)}$) obtained from the wet analysis programme, using the square-root of the summed squares, to derive the final uncertainty values.

Usage

Intended use: With optical emission and X-ray fluorescence spectrometers.

Recommended method of use: Cast irons are generally prepared by grinding. 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 four consistent replicate analyses is recommended to optimise precision and accuracy. 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	Cu
1	3.55	0.434	0.030	0.0538	0.918	0.114	0.477	1.52	0.834
2	3.57	0.44	0.031	0.054	0.926	0.12	0.48	1.53	0.84
3	3.58	0.452	0.033	0.056	0.927	0.12	0.48	1.532	0.86
4	3.59	0.453	0.033	0.057	0.93	0.121	0.481	1.542	0.863
5	3.590	0.47	0.0339	0.0571	0.93	0.122	0.482	1.55	0.864
6	3.609	0.475	0.0356	0.058	0.93	0.126	0.503	1.55	0.872
7	3.61	0.483	0.0358	0.0592	0.936	0.126	0.503	1.556	0.882
8	3.625	0.485	0.036	0.0596	0.94	0.13	0.503	1.56	0.885
9	3.64	0.486	0.036		0.946	0.132	0.505	1.56	0.90
10	3.640		0.0361		0.957		0.512		
Mean	3.600	0.464	0.0340	0.0568	0.934	0.123	0.493	1.544	0.867
Std Dev	0.030	0.020	0.0022	0.0022	0.011	0.006	0.014	0.014	0.021
C (95%)	0.021	0.015	0.0016	0.0018	0.008	0.004	0.010	0.011	0.016

Sample	Sn	Al	Ti	V	Nb	Co	W	Pb	As
1	0.0567	0.0076	0.136	0.0569	0.0069	0.077	0.014	0.0007	0.046
2	0.057	0.009	0.137	0.06	0.0072	0.0789	0.014	0.0007	0.0505
3	0.0572	0.0125	0.139	0.0618	0.0079	0.0826	0.0142	<0.001	0.0519
4	0.060	0.013	0.139	0.062	0.0081	0.085	0.0161	<0.001	0.052
5	0.060	0.0136	0.14	0.062	0.0083	0.087	0.0173	<0.001	0.0530
6	0.061	0.0149	0.14	0.0628	0.009	0.0891	0.0180	<0.005	0.0533
7	0.0615	0.018	0.142	0.0632	0.010	0.09	<0.05	<0.005	0.0551
8	0.062	0.02	0.143	0.064		0.092			
9	0.0663		0.145	0.0645		0.0946			
10	0.0672		0.151	0.065					
Mean	0.0609	0.0136	0.141	0.0622	0.0082	0.0862	0.0156	(0.0007)	0.0517
Std Dev	0.0036	0.0042	0.004	0.0024	0.0011	0.0059	0.0018	-	0.0029
C (95%)	0.0026	0.0035	0.003	0.0017	0.0010	0.0045	0.0019	-	0.0027

Sample	Zr	Sb	Bi	Se	Te	Zn	B	N
1	0.0137	0.002	0.015	0.0167	0.0152	0.0252	0.0048	0.0023
2	0.0140	0.0020	0.0169	0.017	0.0152	0.028	0.0051	0.0024
3	0.0152	0.0023	0.022	0.0171	0.0161	0.028	0.0052	0.0027
4	0.0156	0.0024	0.0238	0.018	0.0162	0.0289	0.0052	0.0033
5	0.016	0.0025	0.0241	0.018	0.0169	0.0294	0.0052	0.0045
6	0.0161	0.0030	0.026	0.0184	0.0191	0.030	0.0055	0.005
7	0.0170		0.0263	0.0187		0.0315	0.0056	
8	0.018			0.019				
9	0.019							
Mean	0.0161	0.0024	0.0220	0.0179	0.0165	0.0287	0.0052	0.0034
Std Dev	0.0017	0.0004	0.0044	0.0008	0.0015	0.0020	0.0003	0.0011
C (95%)	0.0013	0.0004	0.0041	0.0007	0.0015	0.0018	0.0002	0.0012

Participating Laboratories

Zurich Certification Ltd
 AllVac SMP Ltd
 IncoTest Ltd
 Bodycote Materials Testing Ltd
 Sheffield Assay Office
 Rotech Laboratories Ltd
 Laboratory Testing Inc
 Ithaca Materials Research & Testing
 Universal Scientific Laboratory Pty Ltd
 Central Iron & Steel Research Inst
 Institute of Iron & Steel Technology
 Anglo-American Research Labs Pty Ltd

West Bromwich, England
 Sheffield, England
 Hereford, England
 Middlesbrough, England
 Sheffield, England
 Wednesbury, England
 Hatfield, PA, USA
 Lansing, NY, USA
 Milperra, NSW, Australia
 Beijing, China
 Shanghai, China
 Johannesburg, South Africa

UKAS accreditation 0584
 UKAS accreditation 1385
 UKAS accreditation 0281
 UKAS accreditation 0239
 UKAS accreditation 0012
 UKAS accreditation 0366
 A2LA accreditation 0117
 A2LA Accreditation 1140
 NATA accreditation 0492
 CNACL accreditation 0435
 CNACL accreditation 0783

Note: to achieve National Accreditation (eg UKAS, A2LA, NATA, CNACL), test houses must demonstrate conformity to the general requirements of EN ISO/IEC 17025 and ISO9002.

Analytical Methods Used

ELEMENT	RESULT No. & METHOD		
	ICP-AES	FAAS	OTHER
Carbon	-	-	all combustion (infra-red detection)
Silicon	5, 6, 8, 9	-	1, 2, 3, 4, 7 gravimetric (perchloric acid)
Sulfur	-	-	all combustion (infra-red detection)
Phosphorus	1, 4-6, 8	-	2, 3, 7 photometric (molybdenum blue)
Manganese	1, 5-7, 9, 10	3, 4	2, 8 photometric (periodate)
Nickel	1, 2, 4, 7-9	3, 6	5 photometric (dimethyl glyoxime)
Chromium	1, 3, 4, 7-9	10	2, 5, 6 volumetric (ferrous ammonium sulfate)
Molybdenum	1, 3, 4, 6-9	2	5 photometric (thiocyanate)
Copper	1, 2, 5-7, 9	3, 4	8 photometric (bis-cyclohexanone oxalyldihydrazone)
Tin	1, 5-10	2	4 photometric (phenylfluorone); 3) ICP-MS
Aluminium	3, 4, 5, 6, 7, 8	1, 2	
Titanium	1, 2, 4-6, 8, 10	3	7, 9 photometric (di-antipyryl methane)
Vanadium	2, 3, 5-9	4, 10	1 photometric (N-benzoyl phenylhydroxylamine)
Niobium	1, 2, 3, 4, 5, 6	-	7 photometric (4-p.a.resorcinol)
Cobalt	2, 3, 5-9	1, 4	
Tungsten	all	-	
Lead	2, 3, 4, 5, 6, 7	1	
Arsenic	1, 3, 4, 5, 6, 7	2	
Zirconium	1-4, 6-9	-	5 photometric (xylenol orange)
Antimony	2, 3, 4, 5, 6	1	
Bismuth	1, 2, 4, 5, 6, 7	3	
Selenium	3, 5, 6, 7, 8	2	1 GF-AAS; 4) XRF
Tellurium	2, 3, 4, 5, 6	1	
Zinc	1, 3, 5, 6, 7	4	2 XRF
Boron	2, 4, 5, 6, 7	-	1, 3 photometric (circumin, dianthrime)
Nitrogen	-	-	all inert gas fusion (thermal conductivity)

Notes

This Certified Reference Material has been produced and certified in accordance with the requirements of ISO Guide 34-2000, ISO Guide 31-2000 and ISO Guide 35-1989, taking into account the requirements of ASTM E1724, ASTM E1831 and the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

The combination of alloying elements used in a complex material of this type, coupled with the unidirectional solidification effects associated with chill casting, may lead 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 ~5mm, 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. This certification will therefore expire in September 2023, 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.