

CERTIFICATE OF ANALYSIS

12X 357 (batch C)

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	0.270	0.153	0.0590	0.0101	0.220	0.0954	0.094	0.0105
Uncertainty ²	0.004	0.003	0.0017	0.0004	0.004	0.0016	0.002	0.0003

Element	Cu	Co	Sn	Al	W	Ti	V	Nb
Value ¹	0.265	0.199	0.0188	0.208	0.0194	0.0569	0.166	0.0051
Uncertainty ²	0.002	0.003	0.0006	0.010	0.0009	0.0015	0.003	0.0005

Element	As	Pb	Bi	Se	Sb	Zn	B	N
Value ¹	0.0147	0.0315	0.0058	(0.004)	0.0140	0.0094	0.0102	0.0079
Uncertainty ²	0.0008	0.0014	0.0005	-	0.0006	0.0007	0.0005	0.0006

Note: ^{1,2} : for definitions, see page 2.

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

Certified by:

MBH ANALYTICAL LIMITED _____

on 29th September 2015

C Eveleigh

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

Samples for wet chemical analysis were taken from several positions within the batch. In addition, approximately 15% of all discs were selected for homogeneity checking.

Homogeneity and Uncertainty

Samples representative of the batch were checked for uniformity using an optical emission spectrometer. Using the combined data from each surface, standard deviation values were derived for each element.

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.

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.

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 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.

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.

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% 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.

These values have been modified to incorporate statistical analysis of the homogeneity check data, as described above.

Analytical Data

Percentage element by weight

Sample	C	Si	S	P	Mn	Ni	Cr	Mo
1	0.2580	0.1460	0.0562	0.0091	0.2150	0.0915	0.0899	0.0100
2	0.2620	0.1463	0.0566	0.0092	0.2157	0.0931	0.0900	0.0100
3	0.2645	0.1507	0.0569	0.0094	0.2160	0.0935	0.0903	0.0101
4	0.2676	0.1510	0.0570	0.0095	0.2167	0.0935	0.0906	0.0101
5	0.2680	0.1520	0.0571	0.0096	0.2170	0.0939	0.0914	0.0104
6	0.2690	0.1520	0.0574	0.0102	0.2170	0.0957	0.0924	0.0104
7	0.2698	0.1527	0.0585	0.0102	0.2200	0.0974	0.0926	0.0105
8	0.2700	0.1530	0.0590	0.0103	0.2203	0.0974	0.0930	0.0105
9	0.2720	0.1558	0.0604	0.0103	0.2220	0.0976	0.0937	0.0107
10	0.2720	0.1561	0.0604	0.0106	0.2223	0.0978	0.0962	0.0108
11	0.2730	0.1584	0.0609	0.0107	0.2227	0.0984	0.0987	0.0108
12	0.2750	0.1584	0.0614	0.0109	0.2234		0.0988	0.0109
13	0.2772	0.1593	0.0617	0.0116	0.2250		0.0988	0.0110
14	0.2801		0.0626		0.2260			0.0111
Mean	0.2699	0.1532	0.0590	0.0101	0.2199	0.0954	0.0936	0.0105
Std Dev	0.0058	0.0043	0.0022	0.0007	0.0037	0.0024	0.0034	0.0004
C (95%)	0.0034	0.0027	0.0013	0.0004	0.0021	0.0016	0.0021	0.0002

Sample	Cu	Co	Sn	Al	W	Ti	V	Nb
1	0.2586	0.1903	0.0164	0.1988	0.0175	0.0530	0.1569	0.0039
2	0.2601	0.1939	0.0178	0.1998	0.0181	0.0541	0.1590	0.0041
3	0.2612	0.1939	0.0178	0.2020	0.0182	0.0545	0.1618	0.0043
4	0.2622	0.1943	0.0182	0.2041	0.0183	0.0556	0.1620	0.0045
5	0.2627	0.1943	0.0186	0.2060	0.0189	0.0560	0.1624	0.0045
6	0.2630	0.1950	0.0186	0.2074	0.0190	0.0563	0.1650	0.0050
7	0.2639	0.1967	0.0187	0.2077	0.0194	0.0569	0.1651	0.0051
8	0.2655	0.1990	0.0187	0.2083	0.0195	0.0569	0.1652	0.0052
9	0.2663	0.2000	0.0188	0.2096	0.0197	0.0581	0.1655	0.0055
10	0.2678	0.2010	0.0189	0.2104	0.0201	0.0584	0.1683	0.0057
11	0.2680	0.2015	0.0192	0.2150	0.0201	0.0597	0.1690	0.0062
12	0.2695	0.2021	0.0193	0.2160	0.0202	0.0601	0.1701	0.0062
13	0.2700	0.2044	0.0201	0.2176	0.0203	0.0601	0.1706	0.0062
14	0.2705	0.2085	0.0202		0.0206		0.1710	
15		0.2099	0.0205		0.0207		0.1720	
Mean	0.2650	0.1990	0.0188	0.2079	0.0194	0.0569	0.1656	0.0051
Std Dev	0.0038	0.0057	0.0010	0.0059	0.0010	0.0023	0.0046	0.0008
C (95%)	0.0022	0.0031	0.0006	0.0036	0.0006	0.0014	0.0024	0.0005

Sample	As	Pb	Bi	Se	Sb	Zn	B	N
1	0.0137	0.0284	0.0045	0.0028	0.0123	0.0080	0.0087	0.0070
2	0.0139	0.0290	0.0048	0.0030	0.0124	0.0083	0.0091	0.0071
3	0.0140	0.0297	0.0050	0.0032	0.0131	0.0086	0.0094	0.0074
4	0.0144	0.0298	0.0053	0.0032	0.0139	0.0087	0.0098	0.0075
5	0.0145	0.0304	0.0056	0.0034	0.0139	0.0089	0.0102	0.0076
6	0.0148	0.0315	0.0058	0.0046	0.0141	0.0092	0.0102	0.0079
7	0.0148	0.0317	0.0059	0.0046	0.0143	0.0093	0.0104	0.0083
8	0.0149	0.0321	0.0061	0.0047	0.0145	0.0096	0.0105	0.0087
9	0.0150	0.0322	0.0061	0.0051	0.0145	0.0098	0.0105	0.0095
10	0.0150	0.0326	0.0061		0.0146	0.0100	0.0106	
11	0.0152	0.0329	0.0067		0.0153	0.0104	0.0108	
12	0.0155	0.0331	0.0071		0.0155	0.0110	0.0112	
13	0.0157	0.0338				0.0110	0.0112	
14		0.0339						
Mean	0.0147	0.0315	0.0058	0.0038	0.0140	0.0094	0.0102	0.0079
Std Dev	0.0006	0.0018	0.0008	0.0009	0.0010	0.0010	0.0008	0.0008
C (95%)	0.0004	0.0010	0.0005	0.0007	0.0006	0.0006	0.0005	0.0006

Participating Laboratories

Exova Ltd Sheffield Assay Office Birmingham Assay Office Metals Technology (Testing) Ltd Universal Scientific Laboratory Genitest, Inc Shanghai Jinyi Test Technology Co Shandong Metallurgical & Science Research Bureau Veritas CPS Pvt Ltd TCR Engineering Services Ltd Raghavendra Spectrometallurgical Lab. Instytut Metalurgii Zelaza Tec-Eurolab London & Scandinavian Met Co Ltd Coleshill Laboratories Ltd Analyticka Laborator Lithea sro	Middlesbrough, England Sheffield, England Birmingham, England Sheffield, England Milperra, NSW, Australia Montreal, Canada Shanghai, China Jinan, Shandong, China Chennai, India Mumbai, India Bangalore, India Gliwice, Poland Campogalliano, Italy Rotherham, England Birmingham, England Brno, Czech Republic	UKAS accreditation 0239 UKAS accreditation 0012 UKAS accreditation 0667 UKAS accreditation 0963 NATA accreditation 0492 PRI accreditation 123077 CNAL accreditation 0783 CNAS accreditation 1461 NABL accreditation 0025 NABL accreditation 0367 NABL accreditation 0371 PCA accreditation AB554 ACCREDIA accreditation 52
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Note: to achieve the above accreditation (eg UKAS, NATA, etc), test houses are required to 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 (IR or volumetric detection)
Silicon	1, 2, 7-10, 13	-	3, 11, 12 gravimetric (perchloric acid) 4-6 photometric (molybdenum blue)
Sulfur	1, 3	-	2, 4-14 combustion (IR or volumetric detection)
Phosphorus	1, 4, 9-13	-	2, 3, 6 volumetric (alkalimetric) 5, 7, 8 photometric (molybdenum blue)
Manganese	2-5, 8-11, 13	1, 7	6, 12 photometric (periodate) 14 volumetric (arsenite)
Nickel	1, 2, 4-7, 9	3, 10	8, 11 photometric (dimethyl glyoxime)
Chromium	2-6, 8-13	1, 7	
Molybdenum	2, 3, 6, 8, 9, 11-14	1, 5, 7	4, 10 photometric (thiocyanate)
Copper	1-3, 5, 7-12, 14	4, 6	13 photometric (BCO)
Cobalt	2, 3, 5-7, 10-12, 14, 15	4, 9, 13	1 volumetric (iodine) 8 photometric (2β naphthol)
Tin	1-6, 8, 10, 12-15	7, 9, 11	
Aluminium	1, 2, 4-7, 9, 11 13	8, 10	3, 12 photometric (chrome azurol S)
Tungsten	1-5, 7, 9-12, 14, 15	6	13 photometric (thiocyanate); 8: ICP-MS
Titanium	1-3, 7-10, 13	4, 11	5, 6 photometric (diantipyryl methane); 12: ICP-MS
Vanadium	1, 3-8, 10-12, 14, 15	2, 9, 13	
Niobium	1, 3, 5, 6, 8-13	2, 4	7 photometric (chlorosulfophenol)
Arsenic	1-8, 10-13	9	
Lead	1, 3, 5-9, 11-14	2, 4, 10	
Bismuth	1-3, 5-9, 11	4, 10, 12	
Selenium	1, 3, 4, 6-9	2, 5	
Antimony	3-8, 10-12	1, 2, 9	
Zinc	1-4, 6, 7, 9-13	5, 8	
Boron	1-3, 5-13	4	
Nitrogen		-	1-5 inert gas fusion (thermal conductivity detection) 7, 8 volumetric (hydrochloric acid) 6, 9 photometric (Nessler reagent)

Notes

This Certified Reference Material has been produced and certified, wherever possible, 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 September 2035, 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.