

# CERTIFICATE OF ANALYSIS

**12X 355 (batch C)**

## Certified Reference Material Information

Type: LOW-ALLOY STEEL (WROUGHT)  
Form and Size: Disc ~40mm Diameter  
Manufactured by: Instytut Metalurgii Zelaza, Poland  
Certified and Supplied by: MBH Analytical Ltd

## Assigned Values

### Percentage element by weight

Element	C	Si	S	P	Mn	Ni	Cr	Mo
Value <sup>1</sup>	0.159	0.494	0.0241	0.0214	0.508	0.0710	0.113	0.1010
Uncertainty <sup>2</sup>	0.004	0.006	0.0009	0.0008	0.003	0.0008	0.002	0.0009

Element	Cu	Co	Sn	W	Ti	V	As
Value <sup>1</sup>	0.657	0.0495	0.0564	0.037	0.153	0.1265	0.0331
Uncertainty <sup>2</sup>	0.005	0.0009	0.0017	0.002	0.003	0.0014	0.0013

Element	Al	Nb	Se	Sb	Zr	B	N
Value <sup>1</sup>	0.1104	0.023	0.0395	0.0796	0.0192	(0.0012)	0.0023
Uncertainty <sup>2</sup>	0.0016	0.002	0.0010	0.0007	0.0007	-	0.0003

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

## Definitions

- <sup>1</sup> 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.
- <sup>2</sup> 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 31st October 2016

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## **Method of Preparation**

This material was produced by vacuum induction melting and ingot casting, followed by hot forging.

## **Sampling**

Samples for wet chemical analysis were taken from several positions within the batch. In addition, approximately 10% of all discs were selected for homogeneity checking.

## **Homogeneity**

Samples representative of the batch were checked for uniformity using an optical emission spectrometer. The testing procedure was in accordance with ASTM E826 and the material found acceptable.

From this test data, through-batch variation values were derived for each element as an indicator of any minor compositional variation (as determined for the specific sample size and other limitations of 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.

## **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.

Of the individual results herein, some have traceability (to the mole) via primary analytical methods. Some are traceable to substances of known stoichiometry. Most have traceability via commercial solutions. Furthermore, some results have additional traceability to NIST standards, as part of the analytical calibration or process control.

## **Estimation of 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 estimates of variation 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: Steels 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.

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-elemental effects.

## Analytical Data

### Percentage element by weight

Sample	C	Si	S	P	Mn	Ni	Cr	Mo
1	0.1510	0.4770	0.0220	0.0198	0.5008	0.0688	0.1089	0.0981
2	0.1550	0.4783	0.0223	0.0202	0.5009	0.0689	0.1090	0.0997
3	0.1550	0.4820	0.0236	0.0205	0.5015	0.0696	0.1095	0.1001
4	0.1570	0.4910	0.0238	0.0206	0.5045	0.0701	0.1103	0.1005
5	0.1570	0.4943	0.0238	0.0209	0.5062	0.0703	0.1105	0.1008
6	0.1600	0.4956	0.0240	0.0213	0.5064	0.0704	0.1117	0.1010
7	0.1610	0.4970	0.0241	0.0217	0.5066	0.0705	0.1140	0.1010
8	0.1613	0.4970	0.0243	0.0222	0.5080	0.0707	0.1145	0.1013
9	0.1630	0.4975	0.0245	0.0226	0.5080	0.0712	0.1150	0.1020
10	0.1656	0.4978	0.0251	0.0228	0.5110	0.0716	0.1151	0.1021
11		0.4998	0.0253	0.0230	0.5127	0.0722	0.1154	0.1025
12		0.5007	0.0258		0.5150	0.0722	0.1168	0.1030
13		0.5110			0.5155	0.0725	0.1178	
14						0.0728		
15						0.0731		
<b>Mean</b>	<b>0.1586</b>	<b>0.4938</b>	<b>0.0241</b>	<b>0.0214</b>	<b>0.5075</b>	<b>0.0710</b>	<b>0.1129</b>	<b>0.1010</b>
<b>Std Dev</b>	0.0044	0.0096	0.0011	0.0011	0.0050	0.0014	0.0031	0.0013
<b>C<sub>(95%)</sub></b>	0.0031	0.0058	0.0007	0.0007	0.0030	0.0008	0.0019	0.0009

Sample	Cu	Co	Sn	W	Ti	V	As
1	0.6503	0.0475	0.0522	0.0331	0.1450	0.1236	0.0300
2	0.6510	0.0477	0.0529	0.0333	0.1483	0.1240	0.0304
3	0.6520	0.0477	0.0531	0.0337	0.1500	0.1240	0.0314
4	0.6520	0.0484	0.0539	0.0337	0.1502	0.1243	0.0321
5	0.6523	0.0490	0.0542	0.0347	0.1503	0.1255	0.0327
6	0.6550	0.0491	0.0552	0.0363	0.1510	0.1258	0.0328
7	0.6604	0.0492	0.0555	0.0367	0.1513	0.1260	0.0333
8	0.6616	0.0497	0.0568	0.0380	0.1523	0.1262	0.0341
9	0.6617	0.0500	0.0578	0.0382	0.1525	0.1270	0.0345
10	0.6620	0.0502	0.0582	0.0385	0.1544	0.1283	0.0345
11	0.6628	0.0507	0.0583	0.0395	0.1548	0.1289	0.0347
12		0.0517	0.0584	0.0396	0.1550	0.1299	0.0348
13		0.0520	0.0597	0.0399	0.1560	0.1304	0.0353
14			0.0602		0.1597		
15			0.0603		0.1600		
<b>Mean</b>	<b>0.6565</b>	<b>0.0495</b>	<b>0.0564</b>	<b>0.0366</b>	<b>0.1527</b>	<b>0.1265</b>	<b>0.0331</b>
<b>Std Dev</b>	0.0052	0.0015	0.0028	0.0026	0.0040	0.0023	0.0017
<b>C<sub>(95%)</sub></b>	0.0035	0.0009	0.0015	0.0016	0.0022	0.0014	0.0011

Sample	Al	Nb	Se	Sb	Zr	B	N
1	0.1053	0.0190	0.0381	0.0779	0.0178	0.0009	0.0020
2	0.1080	0.0203	0.0382	0.0779	0.0185	0.0009	0.0020
3	0.1080	0.0205	0.0388	0.0789	0.0187	0.0010	0.0021
4	0.1100	0.0206	0.0392	0.0792	0.0188	0.0013	0.0021
5	0.1105	0.0212	0.0394	0.0795	0.0191	0.0014	0.0022
6	0.1105	0.0227	0.0401	0.0798	0.0192	0.0014	0.0024
7	0.1119	0.0235	0.0409	0.0801	0.0194	0.0015	0.0026
8	0.1120	0.0246	0.0412	0.0802	0.0198		0.0028
9	0.1120	0.0257		0.0806	0.0203		
10	0.1128	0.0269		0.0807	0.0204		
11	0.1129	0.0277		0.0809			
<b>Mean</b>	<b>0.1104</b>	<b>0.0230</b>	<b>0.0395</b>	<b>0.0796</b>	<b>0.0192</b>	<b>0.0012</b>	<b>0.0023</b>
<b>Std Dev</b>	0.0024	0.0029	0.0012	0.0010	0.0008	0.0003	0.0003
<b>C<sub>(95%)</sub></b>	0.0016	0.0020	0.0010	0.0007	0.0006	0.0002	0.0003

For the derivation of the 95% confidence interval, C<sub>(95%)</sub>, see page 2

## 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
AnchorCert Analytical	Birmingham, UK	UKAS accreditation	0667
Universal Scientific Laboratory Pty Ltd	Milperra, NSW, Australia	NATA accreditation	0492
Genitest Inc.	Montreal, QC, Canada	PRI accreditation	123077
Shanghai JinYi Test Technology Co. Ltd	Shanghai, China	CNAL accreditation	0783
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS accreditation	1461
Bureau Veritas CPS 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
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		
Coleshill Laboratories Ltd	Coleshill, UK		

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	-	-	1-10 combustion (infra-red detection)
Silicon	1, 2, 5-7, 12, 13	-	3, 4, 8 photometric (molybdenum blue)
			9-11 gravimetric (perchloric acid)
Sulfur	3	-	1, 2, 4-12 combustion (infra-red detection)
Phosphorus	1-4, 6-8, 10, 11	-	5, 9 photometric (molybdenum blue)
Manganese	1, 4-6, 8, 11, 13	3, 9	2, 7, 12 photometric (periodate)
			10 volumetric (arsenite)
Nickel	1, 3, 5-8, 10, 11, 14, 15	2, 9, 12	4, 13 photometric (dimethyl glyoxime)
Chromium	1, 2, 5-7, 10-13	3, 4, 9	8 volumetric (ferrous ammonium sulfate)
Molybdenum	1-5, 7, 8, 10, 11	9	6, 12 photometric (thiocyanate)
Copper	1, 2, 5, 6, 8, 9, 11	4, 7, 10	3 photometric (BCO)
Cobalt	1, 4-7, 9, 10, 12	3, 11, 13	2, 8 photometric (5-CI-PADAP)
Tin	1, 4-15	2, 3	
Tungsten	1, 2, 4-13	3	
Titanium	1-5, 7-11, 14	6, 15	12-13 photometric (diantipyryl methane)
Vanadium	1, 2, 4-7, 10-13	3, 8	9 volumetric (ferrous ammonium sulfate)
Arsenic	1-6, 8-11, 13	7, 12	
Aluminium	1, 5-8, 10, 11	3, 4	2, 9 photometric (chrome azurol S)
Niobium	1-3, 5-8, 10, 11	9	4 photometric (chlorosulfophenol)
Selenium	1, 3-8	2	
Antimony	1-8, 10, 11	9	
Zirconium	1-10	-	
Boron	1-7	-	
Nitrogen	-	-	1 photometric (Nessler reagent)
			2, 3, 7, 8 inert gas fusion (thermal conductivity)
			4-6 Kjeldahl (sulfuric acid)

## 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 OES, it is appropriate to avoid usage of the central portion of ~ 8mm 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 October 2036, although we reserve the right to make changes as issue revisions, in the intervening period.

This material is also available in the form of chippings

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.