

# CERTIFICATE OF ANALYSIS

**13X 31603 (batch C)**

## Certified Reference Material Information

Type: STAINLESS STEEL (WROUGHT)  
Form and Size: Disc, ~30mm diameter  
Manufactured by: Cogne Acciai, Aosta, Italy  
Certified and Supplied by: MBH Analytical Ltd

## Assigned Values

### Percentage element by weight

Element	C	Si	S	P	Mn	Ni	Cr	Mo	Cu
Value <sup>1</sup>	0.023	0.350	0.0245	0.0263	1.879	10.03	16.83	2.02	0.306
Uncertainty <sup>2</sup>	0.002	0.004	0.0008	0.0009	0.011	0.02	0.07	0.01	0.003

Element	Co	V	Nb	W	Al	Sn	Ca	N
Value <sup>1</sup>	0.148	0.0895	0.0197	0.0427	(0.005)	0.0053	0.0029	0.080
Uncertainty <sup>2</sup>	0.002	0.0014	0.0009	0.0015	-	0.0003	0.0003	0.002

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 1<sup>st</sup> December 2016

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## **Method of Preparation**

This reference material was produced from commercial barstock to UNS S31603. The steel was arc-furnace melted, AOD refined and calcium-treated. It was then continuous cast, hot-rolled and cold-finished.

## **Sampling**

Samples for homogeneity checks and milled samples for chemical analysis were taken from multiple positions within the batch.

## **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 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.

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.

## **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-element effects.

## Analytical Data

### Percentage element by weight

Sample	C	Si	S	P	Mn	Ni	Cr	Mo	Cu
1	0.0188	0.3430	0.0224	0.0242	1.8500	9.974	16.711	1.9995	0.2997
2	0.0194	0.3461	0.0225	0.0242	1.8590	10.001	16.740	2.0090	0.2998
3	0.0220	0.3461	0.0237	0.0247	1.8600	10.010	16.743	2.0110	0.3000
4	0.0222	0.3482	0.0239	0.0253	1.8639	10.010	16.750	2.0110	0.3000
5	0.0228	0.3489	0.0239	0.0253	1.8670	10.020	16.790	2.0166	0.3020
6	0.0230	0.3502	0.0248	0.0255	1.8787	10.030	16.793	2.0243	0.3025
7	0.0238	0.3503	0.0249	0.0260	1.8821	10.032	16.833	2.0260	0.3070
8	0.0242	0.3504	0.0250	0.0261	1.8850	10.032	16.835	2.0300	0.3072
9	0.0272	0.3530	0.0251	0.0268	1.8901	10.033	16.848	2.0380	0.3072
10	0.0273	0.3540	0.0252	0.0274	1.8930	10.043	16.874	2.0401	0.3073
11		0.3540	0.0252	0.0274	1.8930	10.050	17.022	2.0413	0.3091
12		0.3560	0.0256	0.0282	1.9010	10.059	17.030	2.0490	0.3093
13		0.3562	0.0260	0.0287	1.9040	10.063			0.3140
14				0.0289					0.3143
15									0.3150
<b>Mean</b>	<b>0.0231</b>	<b>0.3505</b>	<b>0.0245</b>	<b>0.0263</b>	<b>1.8790</b>	<b>10.027</b>	<b>16.831</b>	<b>2.0246</b>	<b>0.3063</b>
<b>Std Dev</b>	0.0028	0.0040	0.0011	0.0016	0.0174	0.025	0.104	0.0155	0.0055
<b>C (95%)</b>	0.0020	0.0024	0.0007	0.0009	0.0105	0.015	0.066	0.0098	0.0030

Sample	Co	V	Nb	W	Al	Sn	Ca	N
1	0.1443	0.0859	0.0179	0.0398	0.0021	0.0051	0.0024	0.0754
2	0.1450	0.0864	0.0182	0.0398	0.0028	0.0051	0.0027	0.0775
3	0.1454	0.0867	0.0185	0.0404	0.0049	0.0052	0.0027	0.0777
4	0.1460	0.0888	0.0186	0.0411	0.0056	0.0052	0.0030	0.0789
5	0.1465	0.0891	0.0186	0.0412	0.0060	0.0054	0.0030	0.0803
6	0.1468	0.0892	0.0191	0.0420	0.0075	0.0054	0.0031	0.0812
7	0.1478	0.0897	0.0191	0.0429	0.0085	0.0055	0.0033	0.0825
8	0.1478	0.0905	0.0198	0.0435		0.0056		0.0829
9	0.1480	0.0914	0.0200	0.0442		0.0056		
10	0.1492	0.0914	0.0201	0.0446				
11	0.1500	0.0921	0.0210	0.0448				
12	0.1505	0.0924	0.0212	0.0453				
13	0.1520		0.0214	0.0459				
14	0.1531		0.0221					
15	0.1540							
<b>Mean</b>	<b>0.1484</b>	<b>0.0895</b>	<b>0.0197</b>	<b>0.0427</b>	<b>0.0053</b>	<b>0.0053</b>	<b>0.0029</b>	<b>0.0796</b>
<b>Std Dev</b>	0.0030	0.0022	0.0013	0.0021	0.0023	0.0002	0.0003	0.0026
<b>C (95%)</b>	0.0016	0.0014	0.0008	0.0013	0.0021	0.0002	0.0003	0.0022

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
Sheffield Analytical Services	Sheffield, UK	UKAS accreditation	0012
Metals Technology (Testing) Ltd.	Sheffield, UK	UKAS accreditation	0963
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
Mineral and Metallurgical Laboratories	Bangalore, India		
AMG Superalloys UK Ltd	Rotherham, UK		
Analyticka Laborator Lithea sro	Brno, Czech Republic		
Coleshill Laboratories Ltd	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	-	-	1-10	combustion (infra-red detection)
Silicon	2, 3, 5-7, 12, 13	-	1, 9, 11 4, 8, 10	photometric (molybdenum blue) gravimetric (perchloric acid)
Sulfur	12	-	1-11, 13	combustion (IR or volumetric detection)
Phosphorus	1, 3, 5, 7-9, 13, 14	-	6, 11-12 2, 4, 10	photometric (molybdenum blue) volumetric (alkalimetric)
Manganese	2-6, 11-12	1, 9	7, 8 10, 13	photometric (periodate) volumetric (arsenite, FAS)
Nickel	3, 4, 8, 10, 13	5	1, 12 2 6, 7, 9, 11	photometric (dimethyl glyoxime) volumetric (dimethyl glyoxime, EDTA) gravimetric (dimethyl glyoxime)
Chromium	2-4, 9, 12	-	1, 5-8, 10, 11	volumetric (ferrous ammonium sulfate)
Molybdenum	1, 2, 5, 7, 11, 12	8, 10	3, 4, 6, 9	photometric (thiocyanate)
Copper	1-3, 6, 8-11, 13, 14	4, 12	5 7, 15	volumetric (thiosulfate) photometric (BCO)
Cobalt	1, 2, 4, 6-8, 10, 12, 14	3, 5, 13	9 11 15	photometric (2 $\beta$ -naphthol) volumetric (iodine) gravimetric (oxide)
Vanadium	2-6, 8, 9, 11, 12	1	7, 10	volumetric (ferrous ammonium sulfate)
Niobium	1-4, 6-11, 13	5	12 14	photometric (chlorosulfophenol) gravimetric (N-benzoylIPH)
Tungsten	1-3, 6-13	5	4	gravimetric (circumin)
Aluminium	2, 3, 5, 6	1, 7	4	photometric (chrome azurol S)
Tin	1-8	9		
Calcium	1, 2, 4-7	3		
Nitrogen	-	-	3, 4, 7, 8 5, 6 1, 2	inert gas fusion (thermal conductivity) volumetric (sulfuric acid) photometric (Nessler reagent)

## 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 ~ 6mm 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 December 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.