

CERTIFICATE OF ANALYSIS

14X HS10 (batch A)

Certified Reference Material Information

Type: TOOL STEEL (HIP)
Form and Size: Disc, 48mm Diameter x 13mm Thickness
Manufactured by: Hoganas GmbH & Bodycote Ltd
Certified and Supplied by: MBH Analytical Ltd

Assigned Values

Percentage element by weight

Element	C	Si	S	P	Mn	Ni	Cr
Value ¹	1.710	0.660	0.0099	0.0135	0.134	0.146	14.83
Uncertainty ²	0.015	0.011	0.0006	0.0013	0.006	0.003	0.11

Element	Mo	Cu	Co	V	W	B	N
Value ¹	1.679	0.0605	0.0866	1.142	1.75	(0.0007)	(0.0013)
Uncertainty ²	0.013	0.0018	0.0018	0.014	0.03	-	-

Note: values 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 _____

on 27th April 2009

C Eveleigh



Method of Preparation

This reference material was produced by water atomisation of molten steel from a 1600kg induction furnace. The resultant powder was dried by vacuum annealing, sealed into cans and HIPped into bars of approximately 30cm length.

Sampling

Samples for chemical analysis were taken from various positions throughout the batch. Approximately 15% of all 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 combined 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 - 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.

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: 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.

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	1.654	0.637	0.0082	0.0104	0.120	0.139	14.57
2	1.669	0.638	0.0082	0.0106	0.121	0.140	14.68
3	1.689	0.650	0.0087	0.0109	0.125	0.140	14.71
4	1.697	0.655	0.0094	0.0135	0.130	0.140	14.72
5	1.71	0.661	0.0095	0.0135	0.130	0.142	14.76
6	1.715	0.665	0.0097	0.0135	0.131	0.145	14.80
7	1.715	0.665	0.010	0.0139	0.132	0.146	14.82
8	1.718	0.674	0.010	0.0140	0.136	0.149	14.98
9	1.720	0.676	0.0103	0.0148	0.138	0.151	15.00
10	1.723	0.680	0.0105	0.0154	0.139	0.152	15.04
11	1.725		0.0106	0.0159	0.148	0.152	15.06
12	1.73		0.011	0.0161	0.152	0.153	
13	1.733		0.0112				
14	1.748		0.0112				
Mean	1.710	0.660	0.0099	0.0135	0.134	0.146	14.83
Std Dev	0.025	0.015	0.0010	0.0020	0.010	0.005	0.16
C_(95%)	0.015	0.011	0.0006	0.0013	0.006	0.003	0.11

Sample	Mo	Cu	Co	V	W	B	N
1	1.646	0.0552	0.0807	1.104	1.680	0.0004	0.0004
2	1.658	0.0572	0.0843	1.112	1.698	0.0005	0.0006
3	1.668	0.0584	0.0844	1.120	1.708	0.0006	0.001
4	1.678	0.0588	0.0857	1.123	1.727	0.0007	0.0014
5	1.680	0.0589	0.0865	1.132	1.739	0.0009	0.0016
6	1.685	0.0591	0.0865	1.140	1.75	0.0009	0.0017
7	1.686	0.0600	0.0866	1.140	1.75	0.0010	0.0022
8	1.691	0.061	0.0870	1.154	1.769	<0.001	
9	1.700	0.0611	0.0871	1.158	1.780	<0.001	
10	1.702	0.063	0.0888	1.159	1.816		
11		0.0631	0.0891	1.162	1.823		
12		0.0646	0.0922	1.162			
13		0.066		1.184			
Mean	1.679	0.0605	0.0866	1.142	1.75	(0.0007)	(0.0013)
Std Dev	0.018	0.0031	0.0028	0.023	0.05	-	-
C_(95%)	0.013	0.0018	0.0018	0.014	0.03	-	-

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

ATI AllVac Ltd	Sheffield, England	UKAS accreditation 1385
Bodycote Materials Testing	Middlesbrough, England	UKAS accreditation 0239
IncoTest Ltd	Hereford, England	UKAS accreditation 0281
Metals Technology (Testing) Ltd	Sheffield, England	UKAS accreditation 0963
Sheffield Assay Office	Sheffield, England	UKAS accreditation 0012
Laboratory Testing, Inc	Hatfield, PA, USA	A2LA accreditation 0117
Universal Scientific Laboratory	Milperra, NSW, Australia	NATA accreditation 0492
Genitest, Inc	Montreal, Canada	PRI accreditation 123077
Institute of Iron and Steel Technology	Shanghai, China	CNAL accreditation 0783
Luo Yang Copper Co	Luo Yang, He Nan, China	CNAL accreditation 0173
Sargam Metals Pvt Ltd	Chennai, India	NABL accreditation 0025
TCR Engineering Services Ltd	Mumbai, India	NABL accreditation 0367
Raghavendra Spectrometallurgical Lab.	Bangalore, India	NABL accreditation 0371
Shriram Institute for Industrial Research	Delhi, India	NABL accreditation 0045
De Bruyn Spectroscopic Solutions Ltd	Johannesburg, South Africa	

Note: to achieve the above-noted accreditation (eg UKAS, A2LA, 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	1, 7	-	10	photometric (molybdenum blue)
Sulfur	4	-	2-6, 8, 9	gravimetric (perchloric acid)
Phosphorus	2-4, 7, 9, 11, 12	-	1-3, 5-14	combustion (infra-red detection)
Manganese	4-7, 10, 11	1, 2, 8	1, 5, 10	photometric (molybdenum blue)
Nickel	1, 2, 5-7, 10	3, 4, 8, 9, 11	6, 8	volumetric (alkalimetric)
Chromium	1, 3-5	-	3, 9	photometric (periodate)
Molybdenum	1, 7-10	3, 5	12	volumetric (arsenite, ammonium nitrate)
Copper	1, 4, 5, 9-12	2, 3, 6, 7, 13	12	photometric (dimethyl glyoxime)
Cobalt	1, 2, 4-7, 9, 12	3, 8, 10, 11	2, 6-11	volumetric (ferrous ammonium sulfate)
Vanadium	2, 3, 5, 7-9, 12, 13	1, 6, 11	2, 4, 6	photometric (thiocyanate)
Tungsten	1, 2, 4, 7, 10	-	8	photometric (BCO)
Boron	1, 2, 4-9	-	4, 10	volumetric (ferrous ammonium sulfate)
Nitrogen	-	-	5	volumetric (titanium chloride)
			3, 6, 8, 9	gravimetric (cinchonine)
			3	ICP-MS
			1-5	inert gas fusion (thermal conductivity)
			6, 7	photometric (Nessler reagent)

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 the ISO Guide to the Expression of Uncertainty in Measurement (GUM).

This certification is applicable to the whole of the disc although, in accordance with normal procedures when using OES, it is appropriate to avoid sparking the central section of approximately 6mm diameter.

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 April 2029, although we reserve the right to make changes as issue revisions, in the intervening period.

This sample is also available in the form of chippings.

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.