

# CERTIFICATE OF ANALYSIS

## 14X HS9 (batch A)

### Certified Reference Material Information

Type: TOOL STEEL TYPE D7 (HIP)  
Form and Size: Disc 42mm Diameter x 15mm Thickness  
Manufactured by: Hoganas Gmbh & Bodycote Ltd  
Certified and Supplied by: MBH Analytical Ltd

### Certified Analysis

#### Percentage element by weight

Element	C	Si	S	P	Mn	Ni	Cr	Mo
Value <sup>1</sup>	2.14	0.406	0.0126	0.0222	0.259	0.239	12.40	1.11
Uncertainty <sup>2</sup>	0.03	0.010	0.0009	0.0014	0.005	0.006	0.07	0.02

Element	V	Cu	Co	W	Nb	Al	N
Value <sup>1</sup>	4.06	0.039	0.037	0.011	(0.011)	(0.022)	0.032
Uncertainty <sup>2</sup>	0.08	0.004	0.002	0.002	-	-	0.003

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 19th May 2006

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 20% 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. Multiple measurements were taken from each surface.

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**

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.

## **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	Mo
1	2.095	0.388	0.0101	0.0200	0.245	0.227	12.32	1.083
2	2.10	0.398	0.0112	0.0201	0.252	0.228	12.34	1.088
3	2.11	0.400	0.0113	0.0209	0.256	0.233	12.36	1.097
4	2.124	0.402	0.0114	0.0209	0.256	0.234	12.37	1.098
5	2.125	0.405	0.0124	0.0215	0.257	0.234	12.38	1.098
6	2.128	0.407	0.013	0.0221	0.259	0.237	12.40	1.10
7	2.134	0.415	0.0132	0.0228	0.264	0.237	12.41	1.110
8	2.15	0.416	0.0138	0.024	0.265	0.246	12.51	1.115
9	2.184	0.425	0.0140	0.024	0.266	0.248	12.53	1.150
10	2.185		0.014	0.026	0.266	0.25		1.159
11	2.189		0.0141			0.257		1.165
<b>Mean</b>	<b>2.139</b>	<b>0.406</b>	<b>0.0126</b>	<b>0.0222</b>	<b>0.259</b>	<b>0.239</b>	<b>12.40</b>	<b>1.114</b>
<b>Std Dev</b>	0.034	0.011	0.0014	0.0020	0.007	0.010	0.07	0.029
<b>C (95%)</b>	0.023	0.009	0.0009	0.0014	0.005	0.006	0.06	0.020

Sample	V	Cu	Co	W	Nb	Al	N
1	3.974	0.035	0.0325	0.0089	0.0080	0.012	0.0298
2	3.982	0.0352	0.0341	0.0093	0.0087	0.018	0.030
3	3.987	0.036	0.035	0.0100	0.0096	0.018	0.0302
4	4.008	0.0361	0.0362	0.0114	0.0107	0.0183	0.0310
5	4.009	0.0381	0.0376	0.0115	0.0132	0.022	0.0350
6	4.062	0.0399	0.0385	0.0143	0.0147	0.0227	0.0355
7	4.141	0.0451	0.0386			0.0236	
8	4.17	0.0468	0.0387			0.0289	
9	4.20		0.0394			0.0343	
<b>Mean</b>	<b>4.06</b>	<b>0.039</b>	<b>0.0367</b>	<b>0.0109</b>	<b>0.0108</b>	<b>0.022</b>	<b>0.0319</b>
<b>Std Dev</b>	0.09	0.005	0.0024	0.0020	0.0026	0.007	0.0026
<b>C (95%)</b>	0.07	0.004	0.0019	0.0021	0.0028	0.005	0.0027

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
IncoTest Ltd	Hereford, England	UKAS accreditation 0281
Bodycote Materials Testing	Middlesbrough, England	UKAS accreditation 0239
Metals Technology (Testing) Ltd	Sheffield, England	UKAS accreditation 0963
Laboratory Testing Inc	Hatfield, PA, USA	A2LA accreditation 0117
Universal Scientific Laboratory Ltd	Milperra, NSW, Australia	NATA accreditation 0492
Institute of Iron & 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 Pvt Ltd	Mumbai, India	NABL accreditation 0367
De Bruyn Spectroscopic Solutions	Johannesburg, South Africa	
Genitest Inc	Montreal, Canada	

Note: to achieve National Accreditation (eg UKAS, A2LA, NATA, CNAL, NABL), 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	5, 8, 9	-	1, 3, 4, 6	gravimetric (perchloric acid)
			2, 7	photometric (molybdenum blue)
Sulfur	-	-	all	combustion (infra-red detection)
Phosphorus	4-7, 10	-	1, 2, 8, 9	photometric (molybdenum blue)
			3	volumetric (alkalimetric)
Manganese	2-4, 7, 9	1, 6	5	photometric (periodate)
			8, 10	volumetric (arsenite, ammonium nitrate)
Nickel	1-3, 7, 8, 11	4-6, 9, 10		
Chromium	1, 3, 7, 9	-	2, 4-6, 8	volumetric (ferrous ammonium sulfate)
Molybdenum	2, 4, 8-10	1, 6	3, 5, 7, 11	photometric (thiocyanate)
Vanadium	2, 4-6	8, 9	1, 3, 7	volumetric (ferrous ammonium sulfate)
Copper	1-4, 8	5, 6, 7		
Cobalt	1, 3, 4, 6, 7, 9	2, 5, 8		
Tungsten	1, 4, 5, 6	-	2	ICP-MS
			3	photometric (tin dichloride)
Niobium	1-3, 5, 6	-	4	ICP-MS
Aluminium	1, 3, 5-7, 9	2, 4	8	photometric (chrome azurol S)
Nitrogen	-	-	1-5	inert gas fusion (thermal conductivity)
			6	volumetric (hydrochloric acid, after distillation)

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

This certification is applicable to the whole of the disc.

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 May 2026, 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.