

CERTIFICATE OF ANALYSIS

24X 7201 (batch A)

Certified Reference Material Information

Type: NICKEL INCONEL 720-TYPE (HIPped POWDER)
Form and Size: Disc ~40mm diameter
Manufactured by: ATI Crucible Research, Pittsburg, USA
Certified and Supplied by: MBH Analytical Ltd

Assigned Values

Percentage element by weight

Element	C	Si	S	P	Mn	Fe	Cr	Mo
Value ¹	0.0326	0.039	0.0027	0.0030	0.0022	0.09	15.99	3.01
Uncertainty ²	0.0015	0.003	0.0003	0.0004	0.0002	0.01	0.04	0.02

Element	Co	W	Ti	Al	B	Zr	Ni	N
Value ¹	14.79	1.29	5.11	2.47	0.0246	0.0432	57.09	0.0043
Uncertainty ²	0.04	0.04	0.04	0.04	0.0014	0.0010	0.10	0.0007

Definitions

- ¹ The above 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 equivalent to the 95% confidence interval derived from the wet analysis results, after assessment of the homogeneity data, as described on page 2.

Certified by:

MBH ANALYTICAL LIMITED _____

on 9th October 2014

C Eveleigh

Method of Preparation

This reference material was produced by atomisation of molten alloy using pressurized argon. The resultant powder was sieved, and then loaded into a steel container which was vacuum outgassed prior to sealing. The sealed container was HIPped, to achieve 100% consolidation.

Sampling

Samples for chemical analysis, and discs for homogeneity checks, were taken from several positions within the batch. At least 10% of all discs were incorporated into the schedule for homogeneity checking.

Homogeneity

The discs were checked for sample and batch uniformity using an optical emission spectrometer. No significant inhomogeneity was found, and spectrometer performance was similar at all positions within the sample.

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.

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.

Since the complete batch of material has been found to be homogeneous (for the main application envisaged), these 95% confidence intervals have been used directly as an indicator of uncertainty.

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: These alloys are generally prepared by finishing, milling, turning or polishing, but note that liquid coolants or solvents should not be used as part of this process. Otherwise, users are recommended to follow the calibration and sample preparation procedures specified by the relevant instrument manufacturer.

A minimum of three 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	Fe	Cr	Mo
1	0.0289	0.033	0.0020	0.0020	0.0018	0.0797	15.91	2.950
2	0.0290	0.034	0.0022	0.0025	0.0018	0.081	15.92	2.961
3	0.0300	0.0369	0.0024	0.0025	0.0020	0.083	15.92	2.980
4	0.0300	0.0386	0.0026	0.0027	0.0020	0.084	15.96	2.980
5	0.0302	0.040	0.0027	0.0030	0.0020	0.0849	15.98	2.983
6	0.0306	0.041	0.0027	0.0030	0.0021	0.0864	15.98	2.990
7	0.0322	0.041	0.0027	0.0031	0.0022	0.0895	15.98	3.001
8	0.0328	0.0413	0.0028	0.0031	0.0022	0.0924	15.99	3.005
9	0.0330	0.0416	0.0033	0.0037	0.0023	0.0970	16.00	3.008
10	0.0330		0.0033	0.0040	0.0024	0.0975	16.00	3.017
11	0.0350		0.0035		0.0026	0.100	16.00	3.032
12	0.0354				0.0030	0.1020	16.04	3.035
13	0.0355					0.1026	16.04	3.045
14	0.0362						16.08	3.047
15	0.0366						16.11	3.062
Mean	0.0326	0.0386	0.0027	0.0030	0.0022	0.090	15.99	3.006
Std Dev	0.0027	0.0033	0.0005	0.0006	0.0003	0.008	0.06	0.033
C (95%)	0.0015	0.0025	0.0003	0.0004	0.0002	0.005	0.03	0.018

Sample	Co	W	Ti	Al	B	Zr	Ni	N
1	14.67	1.200	4.971	2.370	0.0202	0.0402	56.82	0.0030
2	14.67	1.217	4.980	2.385	0.0216	0.0410	56.89	0.0036
3	14.68	1.220	5.052	2.396	0.0229	0.0412	56.94	0.0040
4	14.68	1.221	5.069	2.405	0.0230	0.0417	56.94	0.0042
5	14.73	1.237	5.075	2.429	0.0242	0.0418	57.08	0.0045
6	14.74	1.237	5.080	2.439	0.0253	0.0425	57.12	0.0047
7	14.76	1.250	5.084	2.440	0.0255	0.0427	57.13	0.0049
8	14.76	1.283	5.096	2.450	0.0256	0.0430	57.18	0.0058
9	14.79	1.292	5.101	2.490	0.0256	0.0440	57.19	
10	14.80	1.331	5.121	2.520	0.0258	0.0443	57.22	
11	14.82	1.349	5.138	2.523	0.0261	0.0444	57.25	
12	14.83	1.349	5.143	2.530	0.0265	0.0450	57.31	
13	14.87	1.360	5.153	2.546	0.0277	0.0450		
14	14.87	1.375	5.186	2.570		0.0451		
15	14.88	1.384	5.199	2.590		0.0462		
16	14.88	1.385	5.214					
17	14.90		5.220					
18	14.91							
Mean	14.79	1.293	5.111	2.472	0.0246	0.0432	57.09	0.0043
Std Dev	0.08	0.068	0.073	0.071	0.0021	0.0018	0.16	0.0009
C (95%)	0.04	0.036	0.037	0.039	0.0013	0.0010	0.10	0.0007

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
Sheffield Assay Office	Sheffield, England	UKAS accreditation 0012
Metals Technology (Testing) Ltd	Sheffield, England	UKAS accreditation 0963
Universal Scientific Laboratory	Milperra, NSW, Australia	NATA accreditation 0492
Genitest, Inc	Montreal, Canada	PRI accreditation 123077
Laboratory TUV-Nord Czech	Brno, Czech Republic	CAI accreditation 1060
Shanghai Jinyi Test Tech Co	Shanghai, China	CNAS accreditation L0041
Shandong Metallurgical & Science Research	Jinan, Shandong, China	CNAS accreditation 1461
Sargam Metals Pvt Ltd	Chennai, India	NABL accreditation 0025
TCR Engineering Services Ltd	Mumbai, India	NABL accreditation 0367
Shriram Institute for Industrial Research	Delhi, India	NABL accreditation 0045
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA accreditation AB554
Shanghai Electric Power Generation Co	Shanghai, China	
London & Scandinavian Met Co	Rotherham, England	
De Bruyn Spectroscopic Solutions Ltd	Johannesburg, South Africa	
Rigaku America Applications Laboratory	Woodlands, TX, USA	
Crucible Materials Corp	Pittsburg, PA, USA	

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	XRF	FAAS	OTHER
Carbon	-	-	-	all combustion (infra-red detection)
Silicon	3-5, 9	-	-	1, 6, 8 gravimetric (perchloric acid)
				2, 7 photometric (molybdenum blue)
Sulfur	-	-	-	all combustion (infra-red detection)
Phosphorus	1, 4-6, 10	8	-	2, 7 photometric (molybdenum blue)
				3 ICP-MS
				9 volumetric (alkalimetric)
Manganese	1-3, 6, 8-10	-	4, 7, 11, 12	5 volumetric (arsenite)
Iron	1, 2, 5, 7, 9-11, 13	12	3, 4, 8	6 photometric (sulfosalicylic acid)
Chromium	2, 3, 6-10, 13-15	4	-	1, 5-7, 11, 12 volumetric (FAS)
Molybdenum	1, 4, 7-9, 13, 14	6, 12	2, 3, 5, 10	11, 15 photometric (thiocyanate)
Cobalt	2, 3, 7, 9, 11-14, 16-18	4, 5	1, 8, 10, 15	6 photometric (2 β-naphthol)
Tungsten	1, 3-5, 7-9, 11-13, 15, 16	2, 6	-	10 volumetric (titanium chloride)
				14 gravimetric (cinchonine)
Titanium	1, 2, 4, 7-14, 16	15	3, 6	5, 17 photometric (DAP)
Aluminium	1-3, 5-7, 9-12, 14	13	4, 15	8 volumetric (EDTA)
Boron	1-12	-	-	13 ICP-MS
Zirconium	1-5, 9-15	7, 8	-	6 ICP-MS
Nickel	2, 5-7, 12	9, 11	-	1, 3, 4, 8, 10 gravimetric (dimethyl glyoxime)
				6 volumetric (EDTA/DMGO)
Nitrogen	-	-	-	all inert gas fusion (thermal conductivity)

Notes

This Certified Reference Material was originally tested and certified in November 2008. This upissued certificate includes further analytical results from four new laboratories. This product has been produced and certified, wherever possible, in accordance with the requirements of ISO Guide 34-2009, ISO Guide 31-2000 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.

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. Technical support for this certification will therefore expire in October 2034, although we reserve the right to make changes as further issue revisions, in the intervening period.

The sampling, 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.