

## Certificate of Analysis

### MBH 13X PH4 P

Precipitation Hardening Steel

### Certified Reference Material

Certified Values listed in wt.% with associated uncertainties

<b>Al</b>	<b>0.029 ± 0.003</b>	<b>B</b>	<b>0.0031 ± 0.0002</b>	<b>C</b>	<b>0.033 ± 0.003</b>	<b>Co</b>	<b>0.50 ± 0.01</b>
<b>Cr</b>	<b>15.5 ± 0.1</b>	<b>Cu</b>	<b>5.53 ± 0.04</b>	<b>Mn</b>	<b>0.69 ± 0.01</b>	<b>Mo</b>	<b>0.255 ± 0.005</b>
<b>N</b>	<b>0.082 ± 0.002</b>	<b>Nb</b>	<b>0.355 ± 0.007</b>	<b>Ni</b>	<b>4.07 ± 0.05</b>	<b>P</b>	<b>0.021 ± 0.001</b>
<b>S</b>	<b>0.019 ± 0.002</b>	<b>Si</b>	<b>0.64 ± 0.02</b>	<b>Ti</b>	<b>0.075 ± 0.003</b>	<b>V</b>	<b>0.55 ± 0.01</b>

#### Description and Intended Use

This Certified Reference Material has been produced and certified, wherever possible, in accordance with the requirements of ISO 17034 and the associated Guides, taking into account the requirements of the ISO Guide to the Expression of Uncertainty in Measurement (GUM). This CRM may come in the form of a solid disk or chips. The intended use of this CRM may include, but is not limited to, the calibration of instruments and the validation of analytical methods.

#### Instructions for Use

1. The test surface is on the opposite side of the labeled surface, which includes the material identification. The entire thickness of the unit is certified. However, the user is cautioned not to measure disks less than 2 mm thick when using X-ray fluorescence spectrometry. Each packaged disk has been prepared by finishing the test surface using a lathe. The user must determine the correct surface preparation procedure for each analytical technique. The user is cautioned to use care when either resurfacing the disk or performing additional polishing, as these processes may contaminate the surface.
2. The minimum sample size for chips should be individually evaluated based on the analytical technique used; this would typically be greater than 0.1 grams.
3. The material should be stored in a cool, dry location when not in use.
4. Chips are not recommended for gas analysis.

The following data represents all pertinent information reported as it applies to the chemical characterization of this material.

	Al	B	C	Co	Cr	Cu	Mn	Mo	N	Nb	Ni	P	S	Si	Ti	V
1	0.0204	0.0029	0.0278	0.4550	15.200	5.398	0.6730	0.2460	0.0795	0.3441	3.975	0.0185	0.0145	0.5860	0.0680	0.5035
2	0.0222	0.0029	0.0291	0.4858	15.242	5.472	0.6802	0.2487	0.0805	0.3450	3.998	0.0196	0.0158	0.6120	0.0689	0.5327
3	0.0262	0.0029	0.0305	0.4964	15.455	5.487	0.6823	0.2493	0.0813	0.3492	4.031	0.0201	0.0164	0.6152	0.0702	0.5359
4	0.0270	0.0030	0.0307	0.4997	15.528	5.503	0.6830	0.2501	0.0817	0.3496	4.031	0.0201	0.0176	0.6230	0.0722	0.5430
5	0.0277	0.0031	0.0319	0.5020	15.540	5.508	0.6836	0.2530	0.0825	0.3500	4.035	0.0205	0.0186	0.6384	0.0722	0.5475
6	0.0278	0.0032	0.0340	0.5030	15.540	5.523	0.6837	0.2554	0.0855	0.3527	4.053	0.0208	0.0193	0.6440	0.0744	0.5494
7	0.0290	0.0033	0.0346	0.5070	15.550	5.556	0.6870	0.2560		0.3530	4.070	0.0213	0.0203	0.6470	0.0766	0.5500
8	0.0302	0.0035	0.0354	0.5090	15.661	5.563	0.7004	0.2570		0.3610	4.081	0.0215	0.0206	0.6525	0.0771	0.5560
9	0.0311		0.0375	0.5158	15.680	5.565	0.7072	0.2577		0.3680	4.107	0.0218	0.0210	0.6580	0.0800	0.5592
10	0.0322		0.0385	0.5220	15.830	5.604	0.7140	0.2638		0.3763	4.151	0.0223	0.0214	0.6720	0.0807	0.5638
11	0.0398			0.5341		5.612	0.7240	0.2711			4.214	0.0253	0.0216	0.6900	0.0840	0.5767
12														0.7004		
13																
14																
15																
Mean	0.0285	0.0031	0.0330	0.5027	15.523	5.526	0.6926	0.2553	0.0818	0.3549	4.068	0.0211	0.0188	0.6449	0.0749	0.5471
STDV	0.0051	0.0002	0.0036	0.0205	0.191	0.062	0.0163	0.0073	0.0021	0.0104	0.069	0.0018	0.0025	0.0331	0.0052	0.0191
<b>Certified</b>	<b>0.029</b>	<b>0.0031</b>	<b>0.033</b>	<b>0.50</b>	<b>15.5</b>	<b>5.53</b>	<b>0.69</b>	<b>0.255</b>	<b>0.082</b>	<b>0.355</b>	<b>4.07</b>	<b>0.021</b>	<b>0.019</b>	<b>0.64</b>	<b>0.075</b>	<b>0.55</b>
U <sub>CRM</sub>	0.003	0.0002	0.003	0.01	0.1	0.04	0.01	0.005	0.002	0.007	0.05	0.001	0.002	0.02	0.003	0.01
Methods	I,A,W	I	C	I,A,W	I,W	I,A,W	I,A,W	I,A,W	F	I,A,W	I,W	I,W	C,W,I	I,W	I,A,W	I,A,W

Legend: W = Classical, C = Combustion, F = Fusion, A = AA or GFAA, I = ICP or DCP, IM=ICP-MS, D = DC Arc, O = AES, X = XRF, G = GDAES or GDMS, H = Hollow Cathode AES

### Certification Laboratories

Element Ltd	Middlesbrough, England	Sheffield Analytical Services	Sheffield, England
Universal Scientific Laboratory Pty Ltd	Sydney, Australia	Mineral & Metallurgical Laboratories	Bangalore, India
TUV Nord-Czech	Brno, Czech Republic	National R&D Institute for Non-Ferrous Metals	Romania
Scrooby's Laboratory Services	Benoni, South Africa	Instytut Metalurgii Zelaza	Gliwice, Poland
Tec-Eurolab	Campogalliano, Italy	Analyticka Laborator Lithea sro	Brno, Czech Republic
Genitest Inc	Montreal, Canada	AMG Superalloys UK Ltd	Rotherham, England

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-recognized 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.

### Homogeneity and Uncertainty

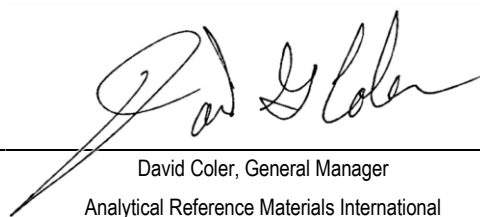
"Uncertainty" values, as reported adjacent to certified concentration values, are based on a 95% Confidence Interval. These estimated uncertainties include the combined effects of method imprecision, material inhomogeneity, and any bias between methods. Homogeneity data from experimental spark OES results are reflected in both the overall statistics and certified data. Homogeneity samples are selected by a systematic sampling procedure. The number of samples may be determined by equation 1, where  $N_{prod}$  is the number of units produced and  $N_{min}$  is the number of samples used for homogeneity testing. These samples are arranged in a simple randomized design such that each sample is analyzed multiple times by spark OES. Homogeneity may also be determined within sample using an applied version of ASTM E826. A single factor ANOVA is used to calculate uncertainty due to inhomogeneity ( $U_{hom}$ ). Uncertainty of the material is calculated by equation 2, where  $H=U_{hom}$ ,  $S$  = Standard deviation,  $t$  = t-value at 95% CI, and  $n$  = number of observations.

$$1. N_{min} = \max(10, \sqrt[3]{N_{prod}})$$

$$2. U_{CRM} = \frac{\sqrt{H^2 + S^2}}{\sqrt{n}} * t$$

### Expiration

The certification of this material is valid indefinitely, within the uncertainty specified, provided the material is handled and stored in accordance with the instructions stated on this certificate. The certification is nullified if the material is damaged, contaminated, otherwise modified, or used in a manner for which it was not intended.

  
 David Coler, General Manager  
 Analytical Reference Materials International