ARMI | MBH

Certified Reference Material

Certificate of Analysis

ISO 17034:2016   ISO/IEC 17025:2017   ISO 9001:2015

Product ID: MBH-32X SN5 C

Product Description: Bronze alloy

Revision No.: 000
Revision Date: 09/08/2022

Description and Intended Use: This **Certified Reference Material** is covered under the scope of accreditation to **ISO 17034** by LGC Standards - Manchester, NH. As an ISO 17034 certified reference material, appropriate use of this material will fulfill the certified reference material and traceability requirements for use in **ISO 17025** accredited laboratories. 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.

Certified Values listed in wt.% with associated uncertainties

Ag	0.082 ± 0.002	Co	0.110 ± 0.003	P	0.017 ± 0.001	Sn	16.7 ± 0.1		
Al	0.89 ± 0.02	Cr	0.011 ± 0.001	Pb	0.27 ± 0.01	Te	0.0013 ± 0.0006		
As	0.053 ± 0.002	Cu	77.2 ± 0.2	S	0.0015 ± 0.0009	Zn	0.815 ± 0.008		
Au	0.011 ± 0.002	Fe	0.95 ± 0.01	Sb	0.69 ± 0.02				
Bi	0.097 ± 0.008	Mn	1.19 ± 0.01	Se	0.0009 ± 0.0004				
Cd	0.121 ± 0.003	Ni	0.382 ± 0.004	Si	0.016 ± 0.001				

Indicative Values listed in ppm

B	(2)	C	(13)	Ge	(10)	In	(6)	Mg	(18)	Zr	(15)

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 XRF 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 XRF. Homogeneity may also be determined within sample using an applied version of ASTM E826. A single factor ANOVA is used to calculated 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.

$$1. N_{MIN} = \max\left(10, \sqrt[3]{N_{PROD}}\right) \qquad 2. U_{CRM} = \frac{\sqrt{H^2 + S^2}}{\sqrt{n}} * t$$

Certification Laboratories: 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.

- AnchorCert Analytical - Birmingham, UK
- Connecticut Metallurgical, Inc. - East Hartford, CT
- Dirats Laboratories - Westfield, MA
- EAG Laboratories - Liverpool, NY
- IMR Test Labs - Lansing, NY
- IMR Test Labs - Louisville, KY
- LGC Standards - Manchester, NH
- Lithea s.r.o. - Brno, Czech Republic
- New Hampshire Materials Laboratory - Somersworth, NH
- NSL Analytical Services - Cleveland, OH
- Scrooby's Laboratory Service - Rynfield, South Africa
- SGS MSi - Melrose Park, IL
- TCR Engineering Services - Maharashtra, India

Instructions for Use: The test surface is on the opposite side of the labeled surface, which includes the material identification. This material is individually chill cast per piece. This manner of casting can cause the formation of inhomogeneous segregates in the upper, engraved portion of the disk. Therefore, the certification information above is not applicable to within 3mm of the engraved surface. 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. 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. The material should be stored in a cool, dry location when not in use.
Chips are not recommended for gas analysis.

Period of Validity: 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.

Chuck Goudreau, Certifying Officer

8 September 2022
Certification Date

ISO 17034 Accredited: Reference Materials Producer, Certificate # 2848.02
ISO/IEC 17025 Accredited: Chemical Testing, Certificate # 2848.01

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

	Ag	Al	As	Au	B	Be	Bi	C	Cd	Co	Cr	Cu	Fe
1	0.0763	0.8068	0.043	0.008	0.0002	<0.0001	0.075	0.0013	0.111	0.0965	0.007	76.65	0.9112
2	0.078	0.832	0.049	0.0081			0.08		0.1139	0.103	0.0095	76.831	0.912
3	0.079	0.83429	0.0501	0.0109			0.0817		0.114	0.105	0.0096	77.016	0.914
4	0.079	0.856	0.05063	0.01115			0.0821		0.117	0.106	0.01	77.145	0.926
5	0.081	0.885	0.051	0.013			0.085		0.12	0.10789	0.01	77.25	0.942
6	0.0821	0.89	0.0511	0.013			0.0887		0.1201	0.109	0.011	77.42	0.945
7	0.08277	0.891	0.0511	<0.010			0.0891		0.121	0.11	0.01104	77.465	0.946
8	0.083	0.8966	0.052				0.09034		0.121	0.11	0.0119	77.51	0.948
9	0.084	0.9	0.0525				0.0933		0.1217	0.1109	0.0119	77.5332	0.954
10	0.0844	0.901	0.0528				0.0977		0.1222	0.111	0.012	77.599	0.957
11	0.085	0.902	0.054				0.099		0.1236	0.1114	0.0131		0.9587
12	0.086	0.902	0.054				0.1		0.125	0.112	0.0142		0.9609
13	0.09	0.9076	0.0546				0.102		0.1289	0.115	0.0158		0.963
14		0.908	0.057				0.114		0.12891	0.115			0.9647
15		0.91	0.058				0.119			0.116			0.96994
16		0.915	0.059				0.119			0.116			0.97
17		0.924	0.059				0.132			0.123			0.972
18		0.925											
19		0.985											
Mean	0.0824	0.8932	0.0529	0.0107	0.0002		0.0969	0.0013	0.1206	0.1105	0.0113	77.24	0.9479
STDV	0.0037	0.0394	0.0040	0.0022			0.0160		0.0053	0.0060	0.0023	0.324	0.0206
Certified	0.082	0.89	0.053	0.011	(0.0002)		0.097	(0.0013)	0.121	0.110	0.011	77.2	0.95
U$_{CRM}$	0.002	0.02	0.002	0.002			0.008		0.003	0.003	0.001	0.2	0.01
Methods	I,IM,G,X,O,A	I,IM,O,G,X	I,IM,O,X	I,IM	I	I	I,IM,O,G,X	C	I,IM,O,G,X	I,IM,O,G,X	I,IM,G,X	I,G,X,O	I,IM,G,O,X

	Ge	In	Mg	Mn	N	Ni	P	Pb	S	Sb	Se	Si	Sn
1	0.001	0.0006	0.0016	1.149	<0.0005	0.372	0.012	0.237	0.0005	0.617	0.0003	0.014	16.175
2			0.002	1.161		0.373	0.0147	0.25	0.0007	0.65	0.00044	0.014	16.48
3			<0.0009	1.165		0.3751	0.015	0.252	0.00114	0.658	0.00074	0.014	16.59
4				1.1689		0.3758	0.015	0.252	0.00195	0.661	0.0009	0.0144	16.59
5				1.169		0.378	0.0159	0.252	0.0023	0.668	0.001	0.015	16.605
6				1.17		0.37833	0.0159	0.2615	0.0024	0.672	0.001	0.015	16.649
7				1.17		0.38	0.0161	0.268	<0.0020	0.673	0.0016	0.015	16.66
8				1.171		0.38	0.017	0.268		0.682	0.0016	0.01619	16.6651
9				1.19		0.38	0.017	0.269		0.6849	<0.0020	0.0162	16.68
10				1.196		0.38	0.01735	0.27		0.695	<0.005	0.017	16.7002
11				1.1964		0.383	0.0175	0.27825		0.6965	<0.0050	0.017	16.7443
12				1.2		0.384	0.018	0.2852		0.701		0.0173	16.7634
13				1.2		0.39	0.018	0.289		0.7028		0.0184	16.878
14				1.2006		0.391	0.0193	0.2902		0.7037		0.0185	17.02
15				1.21		0.394	0.02	0.2935		0.70608		0.0195	17.07
16				1.228		0.401	0.0201	0.297		0.71		0.022	17.09
17				1.239			0.022	0.3034		0.714			
18				1.24498				0.327		0.754			
19													
Mean	0.0010	0.0006	0.0018	1.190		0.3822	0.0171	0.2746	0.0015	0.6861	0.0009	0.0165	16.71
STDV				0.0275		0.0080	0.0024	0.0228	0.0008	0.0303	0.0005	0.0023	0.230
Certified	(0.001)	(0.0006)	(0.0018)	1.19		0.382	0.017	0.27	0.0015	0.69	0.0009	0.016	16.7
U$_{CRM}$				0.01		0.004	0.001	0.01	0.0009	0.02	0.0004	0.001	0.1
Methods	I	I	I,O	I,IM,O,G,X	F	I,IM,O,G,A,X	I,IM,O,G,X	I,IM,O,G,X	C,I	I,IM,O,X,A	IM,I,G,X	I,O,G,IM,X	I,G,O,X

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

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

	Te	Zn	Zr
1	0.001	0.795	0.00008
2	0.001	0.8	0.00023
3	0.001	0.8006	0.0007
4	0.00106	0.8021	0.001
5	0.0011	0.81	0.002
6	0.0011	0.816	0.003
7	0.0013	0.819	0.0037
8	0.003	0.8211	<0.001
9	<0.002	0.8219	<0.001
10	<0.002	0.82754	<0.0010
11	<0.0020	0.829	<0.0010
12	<0.005	0.834	
13			
14			
15			
16			
17			
18			
19			
Mean	0.0013	0.8147	0.0015
STDV	0.0007	0.0129	
Certified	0.0013	0.815	(0.0015)
U_{CRM}	0.0006	0.008	