ARMI | MBH

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Certified Reference Material — Certificate of Analysis

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

Product ID: MBH-FEPIGM-21

Revision No.: 000
Revision Date: 11/15/2022

Product Description: Pig Iron with moderate level elements

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

Al	**0.060**	±0.002	**Mn**	**0.077**	±0.002	**S**	**0.053**	±0.002	**W**	**0.003**	± 0.001
C	**3.22**	±0.03	**Mo**	**0.0157**	±0.0007	**Si**	**0.71**	±0.02	**Zr**	**0.0022**	± 0.0004
Co	**0.015**	±0.001	**Nb**	**0.014**	±0.001	**Sn**	**0.0061**	±0.0007			
Cr	**0.057**	±0.002	**Ni**	**0.028**	±0.004	**Ti**	**0.258**	±0.006			
Cu	**0.0117**	±0.0007	**P**	**0.051**	±0.004	**V**	**0.071**	±0.001			

Indicative Values listed in ppm

As (18) B (4) Ca (11) Fe (Bal) Pb (40) Zn (17)

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, England
- Applied Technical Services - Marietta, GA
- Cleveland Cliffs - West Chester, OH
- Connecticut Metallurgical, Inc. - East Hartford, CT
- EAG Laboratories - Liverpool, NY
- IMR Test Labs - Louisville, KY
- LGC Standards - Manchester, NH
- Lithea S.R.O - Brno, Czech Republic
- Luvak Inc - Boylston, MA
- New Hampshire Materials Laboratory, Inc - Somersworth, NH
- NSL Analytical Services - Cleveland, OH
- Scrooby's Laboratory Service Pty Ltd - Benoni, South Africa
- SGS MSi - Melrose Park, IL
- TCR Engineering Services Pvt Ltd - Mumbai, 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

Chuck Goudreau, Certifying Officer

15 November 2022
Certification Date

ACCREDITED

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

LGC

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

	Al	As	B	C	Ca	Co	Cr	Cu	Mn	Mo	Nb
1	0.0500	0.0004	0.0001	3.170	0.0002	0.0100	0.0500	0.0090	0.0660	0.0130	0.0100
2	0.0510	0.0007	0.0006	3.180	0.0020	0.0110	0.0520	0.0100	0.0710	0.0140	0.0100
3	0.0530	0.0010	<0.0001	3.185		0.0110	0.0534	0.0100	0.0710	0.0140	0.0113
4	0.0530	0.0015		3.197		0.0127	0.0541	0.0100	0.0712	0.0140	0.0120
5	0.0570	0.0016		3.200		0.0130	0.0550	0.0100	0.0730	0.0140	0.0120
6	0.0570	0.0018		3.212		0.0130	0.0551	0.0110	0.0757	0.0144	0.0120
7	0.0580	0.0026		3.218		0.0143	0.0556	0.0112	0.0760	0.0147	0.0120
8	0.0594	0.0029		3.219		0.0144	0.0557	0.0112	0.0760	0.0150	0.0120
9	0.0595	0.0029		3.240		0.0150	0.0560	0.0119	0.0770	0.0150	0.0123
10	0.0600	0.0030		3.241		0.0153	0.0562	0.0119	0.0778	0.0150	0.0124
11	0.0608	<0.0001		3.288		0.0160	0.0570	0.0120	0.0779	0.0153	0.0135
12	0.0609	<0.0006		3.330		0.0160	0.0570	0.0120	0.0780	0.0153	0.0137
13	0.0630	<0.002				0.0160	0.0571	0.0120	0.0782	0.0155	0.0143
14	0.0633	<0.002				0.0160	0.0580	0.0124	0.0790	0.0160	0.0158
15	0.0640	<0.002				0.0160	0.0580	0.0127	0.0791	0.0160	0.0164
16	0.0640	<0.002				0.0161	0.0580	0.0130	0.0793	0.0160	0.0171
17	0.0643	<0.0050				0.0175	0.0580	0.0130	0.0800	0.0160	0.0180
18	0.0657	<0.01				0.0180	0.0605	0.0130	0.0809	0.0165	0.0180
19	0.0670	<0.01				0.0196	0.0610	0.0130	0.0810	0.0170	0.0180
20						0.0199	0.0620	0.0152	0.0830	0.0180	0.0180
21							0.0630			0.0181	0.0180
22							0.0637			0.0190	0.0187
23							0.0640			0.0199	
Mean	0.0595	0.0018	0.0004	3.223	0.0011	0.0150	0.0574	0.0117	0.0766	0.0157	0.0143
STDV	0.0050	0.0010	0.0004	0.046	0.0013	0.0027	0.0036	0.0015	0.0042	0.0017	0.0030
Certified	0.06	(0.0018)	(0.0004)	3.22	(0.0011)	0.015	0.057	0.0117	0.077	0.0157	0.014
U_{CRM}	0.002			0.03		0.001	0.002	0.0007	0.002	0.0007	0.001
Methods	I,G,IM,O,X	I,G,IM,O,A,X	I,O	C,O,I	I,O	I,IM,O,X	I,G,IM,O,X	I,G,IM,O,X	I,G,IM,O,X	I,G,IM,O,X	I,G,IM,O,X

	Ni	P	Pb	S	Si	Sn	Ti	V	W	Zn	Zr
1	0.0240	0.0380	0.0010	0.0447	0.6400	0.0031	0.2330	0.0650	0.0012	0.0002	0.0010
2	0.0241	0.0410	0.0010	0.0480	0.6600	0.0040	0.2350	0.0670	0.0017	0.0012	0.0010
3	0.0255	0.0420	0.0011	0.0497	0.6690	0.0046	0.2460	0.0687	0.0020	0.0012	0.0012
4	0.0260	0.0424	0.0026	0.0500	0.6705	0.0050	0.2500	0.0690	0.0020	0.0012	0.0017
5	0.0260	0.0430	0.0030	0.0500	0.6820	0.0050	0.2510	0.0700	0.0030	0.0013	0.0020
6	0.0260	0.0438	0.0030	0.0520	0.6970	0.0050	0.2510	0.0700	0.0030	0.0020	0.0020
7	0.0260	0.0450	0.0032	0.0520	0.7040	0.0050	0.2510	0.0703	0.0033	0.0021	0.0020
8	0.0268	0.0456	0.0048	0.0533	0.7050	0.0060	0.2550	0.0707	0.0040	0.0028	0.0020
9	0.0270	0.0460	0.0050	0.0535	0.7100	0.0060	0.2590	0.0710	0.0042	0.0033	0.0024
10	0.0275	0.0488	0.0050	0.0539	0.7130	0.0060	0.2600	0.0710	0.0050	<0.0001	0.0025
11	0.0280	0.0494	0.0050	0.0539	0.7180	0.0062	0.2610	0.0710	0.0050	<0.0005	0.0028
12	0.0280	0.0520	0.0050	0.0540	0.7233	0.0062	0.2620	0.0710	0.0060	<0.0010	0.0030
13	0.0281	0.0540	0.0050	0.0542	0.7300	0.0064	0.2620	0.0711	<0.01	<0.002	0.0030
14	0.0281	0.0550	0.0060	0.0570	0.7397	0.0067	0.2649	0.0716		<0.002	0.0031
15	0.0289	0.0560	0.0060	0.0571	0.7400	0.0070	0.2660	0.0720		<0.002	0.0036
16	0.0296	0.0560	0.0080	0.0576	0.7500	0.0074	0.2690	0.0720		<0.01	<0.001
17	0.0298	0.0572	<0.00005	0.0580	0.7530	0.0075	0.2711	0.0720			<0.01
18	0.0298	0.0610	<0.001		0.7650	0.0076	0.2713	0.0729			<0.01
19	0.0300	0.0611	<0.0010		0.7730	0.0080	0.2800	0.0730			
20	0.0310	0.0618				0.0086		0.0770			
21	0.0340	0.0630				<0.01		0.0771			
22	0.0342	0.0637				<0.01		0.0786			
23	0.0351										
Mean	0.0284	0.0512	0.0040	0.0529	0.7128	0.0061	0.2578	0.0715	0.0034	0.0017	0.0022
STDV	0.0030	0.0081	0.0020	0.0036	0.0368	0.0014	0.0121	0.0031	0.0015	0.0009	0.0008
Certified	0.028	0.051	(0.004)	0.053	0.71	0.0061	0.258	0.071	0.003	(0.0017)	0.0022
U_{CRM}	0.004	0.004		0.002	0.02	0.0007	0.006	0.001	0.001		0.0004
Methods	I,G,IM,O,X	I,G,IM,O,X	I,G,IM,O,A,X	C,I,G,O,X	I,G,O,X	I,G,IM,O,A,X	I,G,IM,O,X	I,G,IM,O,X	I,G,IM,O	I,G,IM,O,X	I,G,IM,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