

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS WI-2

Certified Reference Material for White Cast Iron

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values ³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0192	0.0006	Sb	0.023	0.002
As	0.0016	0.0003	Si	0.52	0.02
B	0.0008	0.0003	Sn	0.0042	0.0007
C	3.61	0.02	Ti	0.089	0.004
Co	0.0118	0.0007	V	0.215	0.002
Cr	0.229	0.002	W	0.023	0.001
Cu	0.0124	0.0008	Zr	0.0045	0.0006
Fe	[93.6]	0.4			
Mn	0.80	0.01			
Mo	0.219	0.002			
Nb	0.128	0.004			
Ni	0.254	0.002			
P	0.22	0.01			
Pb	0.013	0.001			
S	0.056	0.001			

Informational Values^{3,4}

Ca (0.00013)

Mg (0.0002)

¹ For each element, the certified value listed is the present best estimate of the true value based on the mean of the weighted results of an interlaboratory testing program. See page 4 for more information on its calculation.

² For each element, the uncertainty listed is based on a statistical evaluation of the contributions of homogeneity and the interlaboratory testing program. See page 4 for more information on its calculation.

³ Values are given in weight percent. Values in brackets are reported by difference.

⁴ Values in parentheses are not certified and are provided for information only.

The requirements of ISO Guides 31, 34, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis. This is a Certified Reference Material as defined by ISO Guide 30.

BS WI-2 * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe
1	4	0.0174	3	0.001	3	0.00076	3	3.57	3	0.01	13	0.2235	3	0.0114	16	[93.515]
2	4	0.0177	3	0.0012	3	0.0008	3	3.58	3	0.0103	3	0.225	3	0.0114	16	[93.57]
3	3	0.0182	3	0.00125	3	0.00086	3	3.58	3	0.0106	3	0.226	3	0.0117	16	[93.65]
4	17	0.01857	3	0.0013	3	0.00088	1	3.581	3	0.0112	3	0.226	3	0.0122	16	[93.66]
5	17	0.0187	3	0.0016	3	0.00091	1	3.5870	3	0.0119	3	0.227	3	0.0122	16	[93.66]
6	3	0.0188	3	0.0016	3	0.00096	3	3.59	3	0.0122	3	0.227	3	0.0126	16	[93.66]
7	3	0.019	3	0.0017	3	0.00097	3	3.59	3	0.0125	7	0.22775	3	0.0127	16	[93.67]
8	3	0.019	3	0.002	3	0.00104	3	3.59	3	0.0128	3	0.228	3	0.0128	16	[93.67]
9	3	0.019	3	0.0021	3	0.00105	3	3.59	3		3	0.228	3	0.0128	16	[93.68]
10	3	0.0192	3	0.0022			3	3.59			4	0.229	3	0.0154	16	[93.68]
11	4	0.0193					1	3.59325			3	0.2290				
12	3	0.0194					18	3.6000			13	0.2295				
13	3	0.0194					1	3.6115			3	0.23				
14	3	0.0194					18	3.61375			4	0.2303				
15	4	0.019975					3	3.62			4	0.23375				
16	4	0.020475					1	3.6225			3	0.234				
17	3	0.0209					3	3.65			4	0.23725				
Average		0.01918		0.00159		0.00084		3.6051		0.01176		0.2288		0.01244		93.642
Std dev		0.00069		0.00020		0.00015		0.0041		0.00047		0.0025		0.00086		0.031
H		0.0009		0.00036		0.00030		0.026		0.000739		0.0036		0.0008		0.54
U ₁		0.0012		0.00041		0.00033		0.027		0.00088		0.0044		0.0011		0.54
t-statistic		2.12		2.26		2.31		2.12		2.36		2.12		2.26		2.26
U ₂		0.0024		0.00093		0.00077		0.057		0.0021		0.0093		0.0026		1.21
U ₃		0.00059		0.00029		0.00026		0.014		0.00073		0.0023		0.00082		0.38
Certified		0.0192		0.0016		0.0008		3.61		0.0118		0.229		0.0124		[93.6]
Uncertainty		0.0006		0.0003		0.0003		0.02		0.0007		0.002		0.0008		0.4
Tolerance		0.0024		0.0009		0.0008		0.06		0.0021		0.009		0.0026		1.2

Analysis	*	Mn	*	Mo	*	Nb	*	Ni	*	P	*	Pb	*	S	*	Sb
1	3	0.783	4	0.21425	3	0.121625	3	0.248	4	0.21075	3	0.0117	3	0.0537	3	0.0192
2	3	0.784	3	0.216	3	0.12275	3	0.25	4	0.211	3	0.0119	1	0.05390	3	0.0218
3	3	0.787	4	0.2165	3	0.123675	4	0.25025	4	0.2146	3	0.012	3	0.054	3	0.0231
4	17	0.78725	3	0.217	3	0.1242	3	0.251	4	0.21525	3	0.0121	1	0.05425	3	0.0234
5	4	0.78725	3	0.217	3	0.124575	3	0.252	7	0.2195	3	0.0121	3	0.0556	3	0.0245
6	3	0.788	3	0.217	3	0.1247	3	0.253	4	0.2195	3	0.0121	1	0.055825	3	0.0248
7	3	0.79	3	0.218	3	0.12475	3	0.253	7	0.221	3	0.0122	1	0.056	3	0.025
8	4	0.79	3	0.218	3	0.124975	3	0.253	3	0.227	3	0.0125	3	0.056	3	0.026
9	4	0.7900	4	0.2185	3	0.12515	4	0.25325	3	0.229	3	0.0129	3	0.05600		
10	3	0.791	3	0.219	3	0.125375	3	0.254	3	0.229	4	0.0129	3	0.0561		
11	3	0.791	3	0.219	3	0.125875	3	0.254	3	0.23	4	0.01375	3	0.0561		
12	3	0.793	3	0.2195	3	0.126275	4	0.2545	3	0.23	4	0.01376	1	0.056225		
13	4	0.79975	3	0.22	3	0.1268	3	0.2545	3	0.231	4	0.01385	3	0.0566		
14	4	0.8030	4	0.2205	3	0.1269	4	0.2565	3	0.231	4	0.0147	1	0.05755		
15	3	0.805	4	0.2230	3	0.127325	7	0.2575	3	0.231	4	0.0151	3	0.0579		
16	4	0.81075	4	0.2230	4	0.12975	7	0.2630	3	0.232	4	0.015175	1	0.0613		
17	3	0.816	4	0.22925	4	0.13250	4	0.26375					3	0.06195		
18					4	0.13275										
19					4	0.13307										
20					4	0.13450										
21					4	0.14000										
22					4	0.14100										
Average		0.7972		0.2192		0.1279		0.2542		0.2232		0.01300		0.0561		0.0227
Std dev		0.0041		0.0025		0.0018		0.0028		0.0029		0.00034		0.0013		0.0019
H		0.0083		0.0035		0.002512		0.0038		0.00353		0.00077		0.0016		0.0010
U ₁		0.0092		0.0043		0.0031		0.0047		0.0046		0.00084		0.0020		0.0021
t-statistic		2.12		2.12		2.08		2.12		2.13		2.13		2.12		2.36
U ₂		0.020		0.0091		0.0064		0.010		0.0097		0.0018		0.0043		0.0050
U ₃		0.0048		0.0022		0.0014		0.0024		0.0024		0.00045		0.0010		0.0018
Certified		0.80		0.219		0.128		0.254		0.22		0.013		0.056		0.023
Uncertainty		0.01		0.002		0.004		0.002		0.01		0.001		0.001		0.002
Tolerance		0.02		0.009		0.006		0.010		0.01		0.002		0.004		0.005

BS WI-2 * Code for method Certified values listed as weight percent

Analysis	*	Si	*	Sn	*	Ti	*	V	*	W	*	Zr
1	3	0.489	3	0.0034	3	0.0832	3	0.211	3	0.0204	3	0.0041
2	3	0.491	3	0.0038	3	0.0837	3	0.211	3	0.0211	3	0.0043
3	3	0.4915	3	0.0038	3	0.084	3	0.211	3	0.0214	3	0.0043
4	3	0.494	3	0.0039	3	0.084	3	0.212	3	0.0217	3	0.0044
5	3	0.495	3	0.0039	3	0.084	3	0.212	3	0.0218	3	0.0045
6	3	0.495	3	0.004	3	0.0841	4	0.21225	3	0.022	3	0.0046
7	3	0.497	3	0.0045	3	0.0842	3	0.213	3	0.0222	3	0.0047
8	3	0.497	3	0.0046	3	0.0845	3	0.213	3	0.0224	3	0.0047
9	3	0.498	3	0.0047	3	0.0853	3	0.214	3	0.023	3	0.0048
10	3	0.498	3	0.005	3	0.0853	3	0.215	3	0.0233	3	0.00485
11	6	0.5265			4	0.093875	13	0.2152	4	0.02364		
12	6	0.52925			4	0.0948	4	0.21675	4	0.02385		
13	6	0.533			7	0.09575	4	0.21725	4	0.0239		
14	6	0.53625			4	0.09585	4	0.21800	4	0.024025		
15	6	0.53825			4	0.0965	3	0.2195	4	0.024125		
16	6	0.5410			7	0.09725	4	0.22025	4	0.02415		
17	6	0.5465			4	0.098425	13	0.22100	4	0.0254		
Average		0.5224		0.00417		0.0887		0.2148		0.02280		0.00450
Std dev		0.0040		0.00092		0.0017		0.0025		0.00059		0.00062
H		0.0062		0.0005		0.00203		0.0034		0.0010		0.00050
U ₁		0.0073		0.0010		0.0026		0.0043		0.0012		0.00080
t-statistic		2.12		2.26		2.12		2.12		2.12		2.26
U ₂		0.016		0.0023		0.0056		0.0090		0.0025		0.0018
U ₃		0.0038		0.00074		0.0014		0.0022		0.00060		0.00057
Certified		0.52		0.0042		0.089		0.215		0.023		0.0045
Uncertainty		0.02		0.0007		0.004		0.002		0.001		0.0006
Tolerance		0.02		0.0023		0.006		0.009		0.003		0.0018

BS WI-2 * Code for method Informational values listed as weight percent

Analysis	*	Ca	*	Mg
1	3	0.00001	3	0.000095
2	3	0.00011	3	0.00012
3	3	0.00011	3	0.00016
4	3	0.00014	3	0.00022
5	3	0.00014	3	0.00025
6	3	0.00015	3	0.00025
7	3	0.00015	3	0.00028
8	3	0.00016	3	0.00028
9	3	0.00018	3	0.00031
Average		0.000128		0.00022
Std dev		0.000031		0.00011
H		0.000207		0.00022
U ₁		0.00021		0.00025
t-statistic		2.31		2.31
U ₂		0.00048		0.00058
U ₃		0.00016		0.00019
(Informational)		(0.00013)		(0.0002)

For each element, in accordance with the requirements of ISO Guides 34 and 35, an effort must be made to account for

the effects on the certified value of the uncertainty estimate from homogeneity testing (H) and the uncertainties of the contributing laboratories. The average (A) is calculated using a weighted mean where the reciprocal of the square of each laboratory's combined uncertainty (C_L), calculated from its standard deviation (S_L) and its uncertainty estimate (U_L), is used as the weight (W_L) for its mean (M_L). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U_1 is the combined uncertainty from homogeneity and labs. U_2 is U_1 multiplied by the coverage factor (95 % t-statistic). U_3 is U_2 divided by the square root of the number of determinations (n). Thus:

$$C_L = \sqrt{S_L^2 + U_L^2} \quad W_L = \frac{1}{C_L^2} \quad A = \frac{\sum_{i=1}^n W_L M_L}{\sum_{i=1}^n W_L} \quad S = \frac{1}{\sqrt{\sum_{i=1}^n W_L}} \quad U_1 = \sqrt{H^2 + S^2} \quad U_2 = t \times U_1 \quad U_3 = \frac{U_2}{\sqrt{n}}$$

All but the final reported values are taken to two significant figures as determined by each quantity's uncertainty estimate. The final reported Uncertainty is U_3 rounded to one significant figure and represents the half width of the 95 % confidence interval for the **Certified** value. The final reported **Certified** value is A rounded to the same decimal place as the Uncertainty. The Tolerance is the half width of the 95 % confidence interval for measurements rounded to the same decimal place as the Uncertainty. The Uncertainty is a measure of the quality of the **Certified** value. The Tolerance is a measure of the expected performance of an analysis.

For further information regarding the confidence interval for the certified value see ISO Guide 35:2006 section 6.

Analytical Method Codes:

1 Combustion (ASTM E1019)	7 Photometric	13 Titrimetric
2 Fusion (ASTM E1019)	8 Flame Atomic Absorption	14 DCP Atomic Emission
3 Spark Atomic Emission	9 GF Atomic Absorption	15 HG Atomic Fluorescence
4 ICP Atomic Emission	10 X-Ray Fluorescence	16 Difference
5 ICP Mass Spectrometry	11 GD Atomic Emission	17 Atomic Absorbption Spectrometry
6 Gravimetric	12 GD Mass Spectrometry	18 Gravimetric

ICP = Inductively Coupled Plasma GF = Graphite Furnace GD = Glow Discharge
DCP = Direct Current Plasma HG = Hydride Generation

<u>Laboratory</u>	<u>Location</u>	<u>Registrar</u>	<u>Accreditation</u>
Shijiazhuang Trump Scientific Co, LTD	Shijiazhuang, China	CNAS	17025
Daye Special Steel Co, LTD	Huangshi, China	CNAS	17025
Chongqing Iron & Steel	Chongqing, China	CNAS	17025
Shanghai Research Institute of Materials	Shanghai, China	CNAS	17025
Benxi Iron & Steel Co, LTD	Benxi, China	CNAS	17025
Zhengzhou Machinery Research Institution	Zhengzhou, China	CNAS	17025
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34

A2LA = American Association for Laboratory Accreditation

CNAS = China National Accreditation Service

Analysis: Chemical analyses were made on solid pieces and chips from representative samples for the certified portion of the lot in accordance with ASTM Standard Practice E1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025.

Traceability and Homogeneity: The following Certified Reference Materials were used to validate the analytical data and homogeneity during testing using ASTM Standard Method E826: BS CC14, CC23, CC22, 2C, 3A, 4B, 4C, 6, 6A; CKD U2, 235; SRM C1150A, 1147, 1149.

Validity statement: ISO Guide 31 states that the certification should contain an expiration date for all materials where instability has

been demonstrated or is considered possible, after which the certified value is no longer guaranteed by the certifying body. The certification of BS WI-2 is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Source: The cast stock for this CRM was produced by Shijiazhuang Trump Scientific Co. LTD; Shijiazhuang, China.

Form: This CRM is machined in the form of a disc, approximately 35 mm in diameter and approximately 30 mm thick by Brammer Standard Company, Inc.

Use: This CRM is intended for use in spark atomic emission, glow discharge, and x-ray spectrometric methods of analysis. Refer to ISO Guide 33 for information about the use of Certified Reference Materials.

Certified Area: The certified area of each disc is the portion extending upward 25mm from the analytical surface.

Sample Preparation: For best analytical results, use the same method for preparing the analytical surface on all reference materials as used for production specimens. Avoid overheating the sample during surface preparation.

Certificate Number: The unique identification number for this certificate of analysis is WI-2-050515. You may obtain information on revisions of certificates from the internet at www.brammerstandard.com.

Safety Notice: A Material Safety Data Sheet (MSDS) is not required for this material. This material will not release or otherwise result in exposure to a hazardous chemical, under normal conditions of use. Inquiries concerning this Reference Material should be directed to:

Brammer Standard Co., Inc. **Phone: (281) 440-9396** **Web: www.brammerstandard.com**
14603 Benfer Road
Houston, Texas 77069-2895 USA **Fax: (281) 440-4432** **Email: contact@brammerstandard.com**

Brammer Standard Company, Inc., is accredited by the American Association For Laboratory Accreditation (A2LA) to ISO Guide 34 as a Reference Material Producer for the production of Certified Reference Materials and Reference Materials (Certificate Number 656.02)

Brammer Standard Company's Chemical Laboratory is accredited by A2LA to ISO Standard 17025. (Certificate Number 656.01)

By Certificate Number 10539, the Quality System of Brammer Standard Company, Inc., is registered to ISO 9001:2008 by National Quality Assurance (NQA), U.S.A.

The scopes of accreditation are listed on the website: www.brammerstandard.com

References:

Versions used were those available at the time of testing and characterization

- E826 Standard Practice for Testing Homogeneity of a Metal Lot or Batch in Solid Form by Spark Atomic Emission Spectrometry
- E1019 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
- E1806 Standard Practice for Sampling Steel and Iron for Determination of Chemical Composition
- ISO Standard 17025:2005 General requirements for the competence of testing and calibration laboratories
- ISO Standard 9001:2008 Quality Management Systems - Requirements
- ISO Guide 30:1992 Terms and definitions used in connection with reference materials + 2008 amendment
- ISO Guide 31:2000 Reference materials - Contents of certificates and labels
- ISO Guide 33:2000 Uses of certified reference materials
- ISO Guide 34:2009 General requirements for the competence of reference material producers
- ISO Guide 35:2006 Reference Materials - General and statistical principles for certification

ASTM documents available from ASTM, 1916 Race Street, Philadelphia, PA, 19103.

ISO Guides and Standards available from Global Engineering - www.global.ihs.com

Other useful documents available from NIST, U.S. Department of Commerce, Gaithersburg, MD 20899.

NIST Special Publication 260-100, Handbook for SRM Users

NIST Special Publication 829, Use of NIST Standard Reference Materials for Decisions on Performance of Analytical Chemical Methods and Laboratories

Certified by: _____ on May 05, 2015.

Beau R. Brammer