

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS WI-1

Certified Reference Material for White Cast Iron

	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	Certified Values <sup>3</sup>	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>
<b>Al</b>	<b>0.075</b>	0.003		<b>Pb</b>	0.003
<b>As</b>	<b>0.0067</b>	0.0005		<b>S</b>	0.003
<b>B</b>	<b>0.0032</b>	0.0005		<b>Si</b>	0.01
<b>C</b>	<b>1.75</b>	0.02		<b>Sn</b>	0.0009
<b>Ca</b>	<b>0.0005</b>	0.0002		<b>Ti</b>	0.002
<b>Co</b>	<b>0.0074</b>	0.0009		<b>V</b>	0.001
<b>Cr</b>	<b>0.048</b>	0.002		<b>W</b>	0.004
<b>Cu</b>	<b>0.027</b>	0.002		<b>Zr</b>	0.0004
<b>Fe</b>	<b>[95.5]</b>	0.4			
<b>Mg</b>	<b>0.0009</b>	0.0003			
<b>Mn</b>	<b>0.24</b>	0.01			
<b>Mo</b>	<b>0.0103</b>	0.0004			
<b>Nb</b>	<b>0.027</b>	0.002			
<b>Ni</b>	<b>0.053</b>	0.002			
<b>P</b>	<b>0.051</b>	0.001			

<sup>1</sup> 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 3 for more information on its calculation.

<sup>2</sup> For each element, the uncertainty listed is based on a statistical evaluation of the contributions of homogeneity and the interlaboratory testing program. See page 3 for more information on its calculation.

<sup>3</sup> Values are given in weight percent. Values in brackets are reported by difference.

Trace element information values for Sb, N, and O are shown on page 3.

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-1** \* Code for method Certified values listed as weight percent

**Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895**  
Telephone: (281) 440-9396 Fax: (281) 440-4432 Website: [www.brammerstandard.com](http://www.brammerstandard.com)  
Certificate Number WI-1-071515 Page 1/6

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu
1	3	0.0621	3	0.0064	3	0.00303	3	1.67	3	0.00039	3	0.0056	13	0.043825	3	0.0257
2	3	0.0661	3	0.0066	3	0.00308	3	1.68	3	0.00043	3	0.0058	4	0.04465	3	0.026
3	3	0.0672	3	0.0066	3	0.00312	3	1.69	3	0.00049	3	0.007	4	0.04595	4	0.026333
4	3	0.0707	4	0.006675	3	0.00318	3	1.7	3	0.00049	3	0.0075	4	0.0472	3	0.0264
5	3	0.072	3	0.0067	3	0.0032	3	1.7	3	0.00049	4	0.008167	4	0.04795	3	0.0265
6	3	0.0725	3	0.0067	3	0.00323	1	1.708	3	0.00051	3	0.0082	7	0.048275	3	0.0266
7	3	0.0753	3	0.0067	3	0.00328	3	1.72	3	0.00051	3	0.0083	13	0.04895	3	0.0268
8	3	0.0764	3	0.0068	3	0.00335	3	1.72	3	0.00052	3	0.009	4	0.0506	3	0.0272
9	3	0.0765	3	0.007	3	0.00337	3	1.73	3	0.00054	3	0.0101	3	0.05561	3	0.0272
10	4	0.07845	3	0.0071			3	1.73			3	0.0107			3	0.0278
11	4	0.078467					1	1.749167								
12	4	0.07905					17	1.76725								
13	4	0.079625					1	1.76875								
14	4	0.079775					1	1.7690								
15	4	0.08009					1	1.7700								
16	4	0.08055					1	1.77825								
17	18	0.08095					17	1.779								
18							1	1.78275								
Average		0.0747		0.00672		0.00320		1.7542		0.000476		0.00743		0.0479		0.0265
Std dev		0.0015		0.00032		0.00053		0.0037		0.000080		0.00037		0.0016		0.0018
H		0.0019		0.00059		0.00045		0.015		0.00026		0.00061		0.0015		0.0011
U <sub>1</sub>		0.0024		0.00067		0.00069		0.015		0.00027		0.00071		0.0022		0.0021
t-statistic		2.12		2.26		2.31		2.11		2.31		2.26		2.31		2.26
U <sub>2</sub>		0.0051		0.0015		0.0016		0.032		0.00063		0.0016		0.0050		0.0048
U <sub>3</sub>		0.0012		0.00048		0.00053		0.0080		0.00021		0.00051		0.0017		0.0015
<b>Certified</b>		<b>0.075</b>		<b>0.0067</b>		<b>0.0032</b>		<b>1.75</b>		<b>0.0005</b>		<b>0.0074</b>		<b>0.048</b>		<b>0.027</b>
<b>Uncertainty</b>		<b>0.003</b>		<b>0.0005</b>		<b>0.0005</b>		<b>0.02</b>		<b>0.0002</b>		<b>0.0009</b>		<b>0.002</b>		<b>0.002</b>
Tolerance		0.005		0.0015		0.0016		0.03		0.0005		0.0016		0.005		0.005

Analysis	*	Fe	*	Mg	*	Mn	*	Mo	*	Nb	*	Ni	*	P	*	Pb
1	16	[5.31667]	4	0.0007	4	0.2275	3	0.0094	3	0.01627	4	0.0500	4	0.04795	3	0.08182
2	16	[95.43]	3	0.00072	4	0.2295	4	0.00961	4	0.0272	4	0.05	4	0.0481	4	0.1110
3	16	[95.46]	3	0.00083	4	0.23	3	0.0097	4	0.027425	4	0.05025	4	0.0486	4	0.1125
4	16	[95.46]	3	0.00087	4	0.2300	3	0.0097	4	0.027775	7	0.0512	4	0.048875	4	0.116633
5	16	[95.47]	3	0.00088	4	0.230033	4	0.0098	4	0.02801	7	0.051825	4	0.049775	4	0.11730
6	16	[95.48]	3	0.00088	4	0.2345	3	0.0098	4	0.02835	4	0.0519	3	0.0505	4	0.1195
7	16	[95.50]	3	0.0009	18	0.23675	3	0.0098	4	0.028775	4	0.0529	4	0.0507	4	0.1210
8	16	[95.51]	3	0.00095	4	0.2370	4	0.0099	4	0.02930	4	0.0537	7	0.05085	4	0.1245
9	16	[95.51]	3	0.00103	3	0.237	3	0.01	4	0.030525	3	0.05478	3	0.0509	4	0.12525
10	16	[95.52]	3	0.00118	3	0.242	3	0.01					3	0.051		
11					3	0.243	3	0.0101					3	0.0512		
12					3	0.243	4	0.01015					4	0.051267		
13					3	0.244	4	0.010175					3	0.0532		
14					3	0.245	3	0.0102					3	0.0533		
15					3	0.248	4	0.01035					3	0.0534		
16					3	0.248	4	0.0108					3	0.0535		
17					3	0.249	4	0.011475					3	0.0537		
Average		95.466		0.00087		0.2372		0.01030		0.0269		0.0525		0.0511		0.1146
Std dev		0.031		0.00036		0.0029		0.00035		0.0010		0.0022		0.0012		0.0027
H		0.54		0.00030		0.0037		0.00070		0.00109		0.0015		0.00151		0.0024
U <sub>1</sub>		0.54		0.00047		0.0047		0.00078		0.0015		0.0026		0.0019		0.0036
t-statistic		2.26		2.26		2.12		2.12		2.31		2.31		2.12		2.31
U <sub>2</sub>		1.23		0.0011		0.010		0.0017		0.0035		0.0061		0.0040		0.0083
U <sub>3</sub>		0.39		0.00034		0.0020		0.00040		0.0012		0.0020		0.00098		0.0028
<b>Certified</b>		<b>[95.5]</b>		<b>0.0009</b>		<b>0.24</b>		<b>0.0103</b>		<b>0.027</b>		<b>0.053</b>		<b>0.051</b>		<b>0.115</b>
<b>Uncertainty</b>		<b>0.4</b>		<b>0.0003</b>		<b>0.01</b>		<b>0.0004</b>		<b>0.002</b>		<b>0.002</b>		<b>0.001</b>		<b>0.003</b>
Tolerance		1.2		0.0009		0.01		0.0017		0.003		0.006		0.004		0.008

BS WI-1

\* Code for method Certified values listed as weight percent

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 Certificate Number WI-1-071515 Page 2/6

Analysis	*	S	*	Si	*	Sn	*	Ti	*	V	*	W	*	Zr
1	3	0.1121	3	1.88	3	0.0076	4	0.018633	3	0.00743	3	0.144941	3	0.0028
2	1	0.14275	3	1.88	3	0.008	4	0.0194	4	0.007867	4	0.18125	3	0.0031
3	1	0.14425	3	1.88	3	0.008	7	0.019575	4	0.008025	4	0.184383	3	0.0032
4	1	0.145	3	1.88	3	0.0081	4	0.019625	4	0.008263	4	0.184	3	0.0033
5	1	0.1455	3	1.88	3	0.0081	4	0.019675	4	0.008403	4	0.18425	3	0.0033
6	1	0.147	3	1.89	3	0.0083	4	0.019875	4	0.008523	4	0.18775	3	0.0035
7	1	0.148333	3	1.89	3	0.0083	7	0.020175	4	0.00877	4	0.18767	3	0.0035
8	1	0.14975	3	1.89	3	0.0085	3	0.0206	4	0.00881	4	0.19075	3	0.0041
9	1	0.15000	4	1.893333	3	0.0085	3	0.0207	4	0.01	4	0.19825	3	0.0044
10	1	0.154	6	1.8935			3	0.0207						
11			3	1.9			3	0.0207						
12			6	1.9010			3	0.0209						
13			6	1.906			4	0.0210						
14			6	1.90625			3	0.0211						
15			6	1.91275			3	0.0211						
16			6	1.928			3	0.0213						
17			6	1.9290			3	0.0213						
Average		0.1443		1.9042		0.00814		0.02032		0.00826		0.1853		0.00342
Std dev		0.0029		0.0039		0.00093		0.00053		0.00028		0.0034		0.00027
H		0.0027		0.01592		0.0006		0.00095		0.00064		0.0032		0.00046
U <sub>1</sub>		0.0040		0.016		0.0011		0.0011		0.00070		0.0047		0.00053
t-statistic		2.26		2.12		2.31		2.12		2.31		2.31		2.31
U <sub>2</sub>		0.0090		0.035		0.0026		0.0023		0.0016		0.011		0.0012
U <sub>3</sub>		0.0028		0.0084		0.00086		0.00056		0.00050		0.0036		0.00041
<b>Certified</b>		<b>0.144</b>		<b>1.90</b>		<b>0.0081</b>		<b>0.020</b>		<b>0.008</b>		<b>0.185</b>		<b>0.0034</b>
<b>Uncertainty</b>		<b>0.003</b>		<b>0.01</b>		<b>0.0009</b>		<b>0.002</b>		<b>0.001</b>		<b>0.004</b>		<b>0.0004</b>
<b>Tolerance</b>		0.009		0.03		0.0026		0.002		0.002		0.011		0.0012

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<sub>L</sub>), calculated from its standard deviation (S<sub>L</sub>) and its uncertainty estimate (U<sub>L</sub>), is used as the weight (W<sub>L</sub>) for its mean (M<sub>L</sub>). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U<sub>1</sub> is the combined uncertainty from homogeneity and labs. U<sub>2</sub> is U<sub>1</sub> multiplied by the coverage factor (95 % t-statistic). U<sub>3</sub> is U<sub>2</sub> 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<sub>3</sub> 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.

**BS WI-1**

\* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Sb	*	N	*	O
1	4	32	2	68.6	2	32.1
2	4	32	2	68.7	2	34.1
3	4	32	2	69.1	2	41.9

**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 Volumetric
6 Gravimetric	12 GD Mass Spectrometry	18 Atomic Absorption Spectrometry

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

<b><u>Laboratory</u></b>	<b><u>Location</u></b>	<b><u>Registrar</u></b>	<b><u>Accreditation</u></b>
Shijiazhuang Trump Scientific Co., LTD	Shijiazhuang, China	CNAS	17025
Daye Special Steel Co., LTD	Huangshi, China	CNAS	17025
Chongqing Iron & Steel Co., LTD.	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
Exova	Glendale Heights, IL	A2LA	17025

A2LA = American Association for Laboratory Accreditation  
CNAS = China National Accreditation Service

**Analysis:** Chemical analyses were made on solid pieces and chips prepared by a lathe 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 CC23, 3A, 4C; CKD U2; 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-1-071515 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 38 mm in diameter and 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-1-071515. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://www.brammerstandard.com).

**Safety Notice:** A Safety Data Sheet (SDS) 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 Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895**  
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Certificate Number WI-1-071515 Page 4/6

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**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](http://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](http://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 July 15, 2015.

Beau R. Brammer