Brammer Standard Company, Inc.

Certificate of Analysis

BS 291DG

Certified Reference Material for Chill-cast Iron

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.0089**	0.0008	**Pb**	**0.0009**	0.0003
As	**0.0017**	0.0004	**S**	**0.0156**	0.0005
B	**0.0089**	0.0004	**Sb**	**0.0024**	0.0004
C	**3.35**	0.01	**Si**	**2.32**	0.01
Ca	**0.0012**	0.0003	**Sn**	**0.0019**	0.0009
Co	**0.0062**	0.0008	**Ti**	**0.0265**	0.0008
Cr	**0.159**	0.002	**V**	**0.013**	0.001
Cu	**0.189**	0.002	**Zr**	**0.0017**	0.0004
Fe	**[93.1]**	0.5			
Mg	**0.042**	0.001			
Mn	**0.456**	0.004			
Mo	**0.0220**	0.0007			
Nb	**0.0024**	0.0004			
Ni	**0.170**	0.002			
P	**0.0216**	0.0007			

Informational Values[3,4]

W (0.002)

[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 3 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 3 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.

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BS 291DG * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu
1	3	0.0086	3	0.0013	3	0.00828	3	3.26	3	0.00056	3	0.0044	3	0.155	3	0.181
2	3	0.0087	3	0.0015	3	0.00829	3	3.27	3	0.0011	3	0.0044	3	0.156	3	0.183
3	3	0.0087	3	0.0016	3	0.00837	3	3.28	3	0.00113	3	0.0057	3	0.156	3	0.183
4	3	0.0092	3	0.0018	3	0.00840	3	3.29	3	0.00113	3	0.0058	3	0.157	3	0.183
5	3	0.0092	3	0.0019	3	0.00842	3	3.31	3	0.00114	3	0.0061	3	0.157	3	0.183
6	3	0.0093	3	0.00211	3	0.00846	3	3.31	3	0.00114	3	0.0076	3	0.157	3	0.184
7	3	0.0105	3	0.0022	3	0.00850	3	3.32	3	0.00118	3	0.0083	3	0.157	3	0.184
8					3	0.00855	1	3.34	3	0.00323			3	0.158	3	0.187
9					3	0.00858	1	3.35075					4	0.16075	4	0.19100
10					3	0.00860	1	3.35425					4	0.16075	4	0.19400
11					3	0.00861	1	3.35775					4	0.16125	4	0.19451
12					3	0.00867	1	3.3585					4	0.1615	4	0.19500
13					3	0.00868	3	3.36					4	0.1617	4	0.19525
14					3	0.00878	1	3.36275					4	0.16175	4	0.19625
15					4	0.008928	1	3.363					4	0.1630	4	0.19775
16					3	0.00894	1	3.38125								
17					4	0.00917										
18					4	0.00925										
19					4	0.009255										
20					4	0.009348										
21					4	0.009365										
22					4	0.009543										
Average		0.00893		0.00172		0.00889		3.3539		0.00118		0.00623		0.1587		0.1887
Std dev		0.00056		0.00022		0.00024		0.0041		0.00016		0.00059		0.0024		0.0027
H		0.00067		0.00037		0.00066		0.0252		0.00034		0.00058		0.0029		0.0032
U_1		0.00087		0.00043		0.00071		0.026		0.00037		0.00082		0.0038		0.0042
t-statistic		2.45		2.45		2.08		2.14		2.36		2.45		2.14		2.16
U_2		0.0021		0.0011		0.0015		0.055		0.00088		0.0020		0.0081		0.0090
U_3		0.00080		0.00040		0.00031		0.014		0.00031		0.00076		0.0021		0.0024
Certified		**0.0089**		**0.0017**		**0.0089**		**3.35**		**0.0012**		**0.0062**		**0.159**		**0.189**
Uncertainty		**0.0008**		**0.0004**		**0.0004**		**0.01**		**0.0003**		**0.0008**		**0.002**		**0.002**
Tolerance		0.0021		0.0011		0.0015		0.05		0.0009		0.0020		0.008		0.009

BS 291DG * Code for method Certified values listed as weight percent

Analysis	*	Fe	*	Mg	*	Mn	*	Mo	*	Nb	*	Ni	*	P	*	Pb
1	16	[92.57]	3	0.04158	3	0.435	3	0.0193	3	0.0016	3	0.167	4	0.01965	3	0.0007
2	16	[93.2]	3	0.041608	3	0.435	3	0.0195	3	0.0022	3	0.167	4	0.0209	3	0.0008
3	16	[93.22]	3	0.041615	3	0.439	3	0.0199	3	0.0024	3	0.168	7	0.021225	3	0.0009
4	16	[93.22]	3	0.041665	3	0.444	3	0.0202	3	0.0024	3	0.168	4	0.0214	3	0.0009
5	16	[93.22]	3	0.04171	3	0.448	3	0.0202	3	0.0026	3	0.169	4	0.021425	3	0.001
6	16	[93.24]	3	0.041713	3	0.449	3	0.0203	3	0.0027	3	0.169	4	0.02155	3	0.0011
7	16	[93.24]	3	0.04175	3	0.453	3	0.0208	3	0.0032	4	0.17025	3	0.0218	3	0.0012
8	16	[93.26]	3	0.041788	3	0.454	3	0.0214			4	0.1706	3	0.0219		
9			3	0.041825	4	0.4555	4	0.02185			4	0.17075	3	0.0219		
10			3	0.041833	4	0.45675	4	0.0220			4	0.17125	3	0.022		
11			3	0.041835	4	0.46	4	0.0223			4	0.1715	3	0.022		
12			3	0.041928	4	0.46325	4	0.022925			4	0.17175	3	0.022		
13			3	0.041928	4	0.46375	4	0.0231			3	0.174	4	0.0221		
14			3	0.041943	4	0.46375	4	0.023925			3	0.175	3	0.0222		
15			3	0.041978	17	0.47775	4	0.025875			4	0.17675				
16			3	0.04199												
17			3	0.042015												
18			3	0.042223												
19			3	0.04225												
20			3	0.04226												
21			3	0.04232												
22			3	0.042375												
23			3	0.042383												
24			3	0.0424												
25			3	0.042425												
26			3	0.042445												
27			3	0.04246												
28			3	0.042468												
29			3	0.042485												
30			3	0.042503												
31			3	0.04253												
32			3	0.042558												
Average		93.146		0.04208		0.4563		0.02203		0.00236		0.1705		0.02159		0.00090
Std dev		0.035		0.00074		0.0038		0.00073		0.00025		0.0027		0.00063		0.00015
H		0.56		0.0014		0.0057		0.0010		0.00041		0.0030		0.00098		0.00031
U_1		0.56		0.0016		0.0068		0.0012		0.00048		0.0040		0.0012		0.00035
t-statistic		2.36		2.04		2.14		2.14		2.45		2.14		2.16		2.45
U_2		1.33		0.0032		0.015		0.0026		0.0012		0.0087		0.0025		0.00085
U_3		0.47		0.00056		0.0038		0.00071		0.00045		0.0022		0.00067		0.00032
Certified		**[93.1]**		**0.042**		**0.456**		**0.0220**		**0.0024**		**0.170**		**0.0216**		**0.0009**
Uncertainty		**0.5**		**0.001**		**0.004**		**0.0007**		**0.0004**		**0.002**		**0.0007**		**0.0003**
Tolerance		1.5		0.003		0.015		0.0027		0.0012		0.009		0.0025		0.0008

BS 291DG * Code for method Certified values listed as weight percent

Analysis	*	S	*	Sb	*	Si	*	Sn	*	Ti	*	V	*	Zr
1	3	0.0135	4	0.002278	6	2.2955	3	0.0017	4	0.025125	3	0.0116	3	0.0016
2	3	0.014	4	0.002305	6	2.2980	3	0.0017	4	0.025725	3	0.0119	3	0.0016
3	3	0.0143	4	0.00236	3	2.3	3	0.0018	4	0.025775	3	0.012	3	0.0016
4	3	0.0145	4	0.0024	6	2.304	3	0.0019	4	0.0258	3	0.0121	3	0.0017
5	3	0.01470	4	0.002438	6	2.30825	3	0.0021	4	0.02585	3	0.0121	3	0.0018
6	1	0.0147	4	0.002573	3	2.32	3	0.0021	4	0.02634	3	0.0122	3	0.0019
7	1	0.0149	17	0.002725	6	2.3260	3	0.0022	4	0.0264	3	0.0123	3	0.0020
8	3	0.0151			3	2.33			3	0.0266	4	0.01230		
9	3	0.0153			3	2.33			3	0.0267	4	0.012975		
10	1	0.015475			6	2.33275			3	0.0269	4	0.01300		
11	1	0.0155			3	2.34			3	0.027	3	0.0139		
12	1	0.01570			3	2.34			3	0.0272	4	0.01405		
13	3	0.0159			6	2.3435			3	0.0275	4	0.0141		
14	1	0.016275			3	2.35			4	0.02795	4	0.015725		
15	1	0.016625			3	2.36					4	0.01590		
16	1	0.01745												
Average		0.01558		0.002425		2.3164		0.00193		0.02650		0.01295		0.00173
Std dev		0.00047		0.000058		0.0045		0.00090		0.00076		0.00037		0.00022
H		0.00084		0.00041		0.019		0.00039		0.00108		0.00078		0.00037
U_1		0.00097		0.00042		0.019		0.00098		0.0013		0.00086		0.00044
t-statistic		2.13		2.45		2.14		2.45		2.16		2.14		2.45
U_2		0.0021		0.0010		0.041		0.0024		0.0029		0.0018		0.0011
U_3		0.00052		0.00039		0.011		0.00090		0.00076		0.00050		0.00040
Certified		**0.0156**		**0.0024**		**2.32**		**0.0019**		**0.0265**		**0.013**		**0.0017**
Uncertainty		**0.0005**		**0.0004**		**0.01**		**0.0009**		**0.0008**		**0.001**		**0.0004**
Tolerance		0.0021		0.0010		0.04		0.0019		0.0029		0.002		0.0011

BS 291DG * Code for method Informational values listed as weight percent

Analysis	*	W
1	3	0.0017
2	3	0.002
Average		0.00185
Std dev		0.00042
H		0.000381
U_1		0.00057
t-statistic		12.71
U_2		0.0072
U_3		0.0051
(Informational)		**(0.002)**

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 it's 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:

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

*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 Absorption Spectrometry
6	Gravimetric	12	GD Mass Spectrometry		

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

Laboratory	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Shijiazhuang Trump Scientific Co, LTD.	Shijiazhuang, China	CNAS	17025
Daye Special Steel Co., LTD.	Huangshi, China	CNAS	17025
Chongqing Iron & Steel Co., LTD.	Chongqin, 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

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: The following Certified Reference Materials were used to validate the analytical data: 501-676; BS CC-23, CC-30, 7, 27, 280A, 281, 281F, 284, 291; CKD 227, 238, 244, 245; ECRM 480-1; SRM C2425A, 338, 1141A.

Homogeneity: This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E826 and found acceptable.

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 291DG 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.

Form: This CRM is machined in the form of a disc, approximately 35 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 291DG-061215. You may obtain information on revisions of certificates from the internet at **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 Co., Inc. **Phone: (281) 440-9396** **Web: www.brammerstandard.com**
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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 June 12, 2015.

Beau R. Brammer