Brammer Standard Company, Inc.

Certificate of Analysis

BS 285BC

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	**0.0157**	0.0007	**Nb**	**0.0039**	0.0005
As	**0.0011**	0.0004	**Ni**	**1.38**	0.04
B	**0.0084**	0.0006	**P**	**0.047**	0.001
C	**3.42**	0.05	**S**	**0.0124**	0.0007
Ca	**0.0008**	0.0002	**Si**	**1.93**	0.02
Cr	**1.05**	0.01	**Sn**	**0.0018**	0.0005
Cu	**0.320**	0.006	**Ti**	**0.043**	0.001
Fe	**90.6**	0.1	**V**	**0.121**	0.002
Mg	**0.047**	0.002	**W**	**0.061**	0.002
Mn	**0.724**	0.008	**Zr**	**0.0054**	0.0005
Mo	**0.237**	0.004			

Informational Values[3,4]

Co (0.003) Pb (0.0006) Sb (0.2)

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 30, 31, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis.

BS 285BC * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Cr	*	Cu	*	Fe	*	Mg	*	Mn
1	5	0.01397	3	0.0004	4	0.00753	3	3.38	4	0.0006	3	1.03	4	0.311667	3	90.49	3	0.04656	14	0.72233
2	3	0.01407	3	0.0006	14	0.0081	1	3.386667	4	0.0006	4	1.0327	10	0.313	3	90.51	3	0.04677	3	0.723
3	3	0.0148	3	0.0007	3	0.00827	1	3.408733	3	0.00085	3	1.04	4	0.3130	3	90.52	3	0.04682	3	0.724
4	3	0.0153	3	0.0008	3	0.00827	3	3.41	3	0.00085	3	1.04	3	0.317	3	90.52	3	0.04691	3	0.727
5	3	0.0156	3	0.0008	3	0.00828	3	3.42	3	0.00085	3	1.04	3	0.318	16	90.5333	3	0.04703	3	0.728
6	3	0.0157	3	0.0012	3	0.00834	1	3.426667	3	0.0009	3	1.04	3	0.319	16	90.5392	3	0.0471	3	0.729
7	4	0.01577	5	0.001233	3	0.00839	3	3.43	3	0.00091	3	1.04	3	0.32	3	90.54	3	0.04726	3	0.73
8	3	0.0159	3	0.0014	3	0.00839	3	3.43	3	0.00091	3	1.04	3	0.32	3	90.55	3	0.04734	3	0.731
9	3	0.0159	5	0.001767	3	0.0084	3	3.43	3	0.00101	10	1.04	3	0.32	3	90.58	3	0.04738	3	0.731
10	4	0.0161	9	0.002	3	0.0084	3	3.44	3	0.00102	3	1.04667	3	0.32	3	90.59			10	0.732
11	3	0.0162	5	0.002067	3	0.00848	3	3.45	14	0.001067	14	1.05	3	0.321	3	90.59			3	0.732
12	3	0.0164			5	0.00862	3	3.45	3	0.00117	3	1.05	3	0.321	14	90.6			4	0.73467
13	14	0.0164			4	0.01043	1	3.466533			3	1.05	14	0.321333	4	90.6067			3	0.741
14	3	0.0164									4	1.06433							4	0.74347
15											4	1.07333								
Average		0.01571		0.001137		0.00837		3.425277		0.00084		1.048		0.3200		90.562		0.0470		0.724
Std Dev		0.00049		0.000093		0.00035		0.000088		0.00011		0.015		0.0074		0.052		0.0016		0.010
H		0.0012		0.00041		0.00089		0.022		0.00037		0.011		0.0054		0.23		0.0020		0.009
U_1		0.0013		0.00042		0.00096		0.022		0.00038		0.018		0.0092		0.23		0.0025		0.013
t-statistic		2.16		2.23		2.18		2.18		2.20		2.14		2.18		2.18		2.31		2.16
U_2		0.0028		0.00094		0.0021		0.049		0.00085		0.039		0.020		0.51		0.0058		0.028
U_3		0.00074		0.00028		0.00058		0.014		0.00024		0.010		0.0055		0.14		0.0019		0.0076
Certified		**0.0157**		**0.0011**		**0.0084**		**3.42**		**0.0008**		**1.05**		**0.320**		**90.6**		**0.047**		**0.724**
Uncertainty		0.0007		0.0004		0.0006		0.05		0.0002		0.01		0.006		0.1		0.002		0.008
Tolerance		0.0028		0.0012		0.0021		0.15		0.0008		0.04		0.020		0.5		0.006		0.028

Analysis	*	Mo	*	Nb	*	Ni	*	P	*	S	*	Si	*	Sn	*	Ti	*	V	*	W
1	5	0.230	3	0.0036	4	1.31233	5	0.038633	3	0.011	3	1.92	5	0.001	4	0.04083	3	0.115	3	0.0587
2	4	0.23123	3	0.0037	10	1.32	3	0.044	1	0.011033	3	1.92	5	0.001033	5	0.04157	5	0.11867	3	0.059
3	3	0.234	4	0.003867	4	1.34643	10	0.044	3	0.0116	3	1.92	10	0.0012	3	0.0421	3	0.12	3	0.0599
4	10	0.235	14	0.003867	4	1.35333	3	0.0466	3	0.0118	14	1.92667	3	0.0013	3	0.0423	3	0.12	10	0.06
5	3	0.236	3	0.0039	3	1.35967	3	0.0466	3	0.0119	3	1.93	3	0.0013	3	0.0424	10	0.12	3	0.0603
6	3	0.237	3	0.0039	3	1.36	3	0.0471	3	0.0124	3	1.93	3	0.0016	3	0.0424	3	0.121	3	0.0603
7	3	0.237	3	0.0039	14	1.38667	14	0.0472	3	0.0125	3	1.93	9	0.001667	10	0.0425	3	0.121	3	0.0607
8	3	0.237	3	0.0039	3	1.39	3	0.0476	1	0.0126	3	1.93	3	0.0019	3	0.0426	3	0.121	3	0.0607
9	3	0.238	3	0.004	3	1.39	3	0.0477	1	0.012667	3	1.93	3	0.002	3	0.0426	3	0.122	4	0.0608
10	14	0.238	3	0.0041	3	1.4	3	0.0477	3	0.0129	3	1.94	3	0.002	14	0.04263	3	0.122	3	0.0608
11	3	0.23867	3	0.0042	3	1.41	3	0.0478	10	0.013	17	1.94883	3	0.0021	3	0.0427	3	0.122	14	0.0608
12	3	0.239			3	1.41	3	0.0482	3	0.0132			5	0.002467	3	0.0427	4	0.1223	3	0.0609
13	3	0.239			3	1.41	3	0.0485	3	0.0132			3	0.0026	4	0.04273	3	0.123	4	0.063
14	4	0.239			3	1.42	4	0.049367	3	0.0133			3	0.003	3	0.0428	14	0.123	3	0.06333
15	3	0.24			3	1.44	4	0.051033							3	0.0428	4	0.12733	5	0.06393
16																				
17																				
18																				
19																				
20																				
Average		0.2374		0.00392		1.380		0.0467		0.01241		1.928		0.001798		0.0425		0.1206		0.0608
Std Dev		0.0051		0.00028		0.021		0.0014		0.00039		0.033		0.000085		0.0012		0.0031		0.0017
H		0.0046		0.000653		0.013		0.001959		0.0011		0.016		0.00048		0.00187		0.0032		0.0022
U_1		0.0069		0.00071		0.024		0.0024		0.0011		0.037		0.00049		0.0022		0.0044		0.0028
t-statistic		2.14		2.23		2.14		2.14		2.16		2.23		2.16		2.14		2.14		2.14
U_2		0.015		0.0016		0.052		0.0051		0.0024		0.082		0.0011		0.0048		0.010		0.0060
U_3		0.0038		0.00048		0.013		0.0013		0.00065		0.025		0.00028		0.0012		0.0025		0.0015
Certified		**0.237**		**0.0039**		**1.38**		**0.047**		**0.0124**		**1.93**		**0.0018**		**0.043**		**0.121**		**0.061**
Uncertainty		0.004		0.0005		0.04		0.001		0.0007		0.02		0.0005		0.001		0.002		0.002
Tolerance		0.015		0.0016		0.12		0.005		0.0024		0.08		0.0015		0.005		0.010		0.006

BS 285BC * Code for method Certified values listed as weight percent

Analysis	*	Zr
1	14	0.00293
2	5	0.0036
3	3	0.0055
4	3	0.0055
5	3	0.0055
6	3	0.0056
7	3	0.0056
8	3	0.0056
9	3	0.0056
10	3	0.0057
11	3	0.0058
12		
13		
14		
15		
16		
17		
18		
19		
20		
Average		0.00538
Std Dev		0.00026
H		0.00074
U_1		0.00079
t-statistic		2.23
U_2		0.0018
U_3		0.00053
Certified		**0.0054**
Uncertainty		0.0005
Tolerance		0.0018

BS 285BC * Code for method Informational values listed as weight percent

Analysis	*	Co	*	Pb	*	Sb
1	3	0.0015	5	0.000153	10	0.2
2	3	0.0019	5	0.000167		
3	3	0.0021	9	0.0002		
4	10	0.0032	5	0.0002		
5	3	0.00337	3	0.0004		
6	4	0.00343	3	0.0005		
7	14	0.0039	3	0.0007		
8	3	0.0041	3	0.0007		
9	3	0.0042	3	0.0007		
10	3	0.0043	3	0.0008		
11	5	0.00467	10	0.0008		
12	3	0.005	3	0.0008		
13			3	0.001		
14			3	0.0012		
15						
16						
17						
18						
19						
20						
Average		0.003		0.00059		0.20
Std Dev		0.016		0.00074		2.18
H		0.001		0.00033		0.00
U_1		0.016		0.00081		2.18
t-statistic		2.20		2.16		12.71
U_2		0.036		0.0017		27.77
U_3		0.010		0.00047		27.77
Informational		(0.003)		(0.0006)		(0.2)

For each element, in accordance with the requirements of ISO 17034 and Guide 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 Uncertainty is a measure of the quality of the **Certified** value.*

The Tolerance is a measure of the expected performance of an analysis. This involves further expanding the sample uncertainty to include instrument and operator uncertainty, for those without access to such calculations.

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	WET
6	Gravimetric	12	GD Mass Spectrometry		

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

Lab Name	Location	Registrar	Accreditation
Dirats Laboratories	Westfield,MA	ANAB	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Luvak Inc.	Boylston, MA	PRI	17025
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034

A2LA = American Association for Laboratory Accreditation
ANAB = ANSI-ASQ National Accreditation Board
PCA = Polish Center For Accreditation
PRI =Performance Review Institute

Analysis: Chemical analyses were made on solid pieces 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: 11XC1N, 11XC2R, 11XC6U, 11XSG1A; AR 303, 306, 510, 892, 4007; BS 5, 27, 45B, 188B, 199B, 285, 285AA, 286AE, 291, 291DJ, 410C, 416, 9325A; CKD 235, 236, 238, 239; SPL 2A, 6A, 15A; SRM 16F, 55D, 82, 361, 362, 363, 2159, 3113.

Homogeneity: This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the following Reference Materials — BS 5, 27, 285, 285AA, 286AE, 291, 291DJ.

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 285BC is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Storage: This CRM must be stored in a cool, dry, non-corrosive environment.

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 25 mm 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 285BC-051818. 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:

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Brammer Standard Company, Inc., is accredited by the American Association For Laboratory Accreditation (A2LA) to ISO Standard 17034 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 by National Quality Assurance (NQA), U.S.A.

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

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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 9001:2015 Quality Management Systems - Requirements

ISO Guide 30:2015 Terms and definitions used in connection with reference materials + 2008 amendment

ISO Guide 31:2015 Reference materials - Contents of certificates and labels

ISO Guide 33:2015 Uses of certified reference materials

ISO Standard 17034:2016 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, 100 Barr Harbor Dr., West Conshohocken, PA 19428.

*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 18, 2018.

Beau R. Brammer

President