

Brammer Standard Company, Inc.

Certificate of Analysis

BS 285BD

Certified Reference Material for Chill Cast Iron

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
Al	0.0160	0.0005		Nb	0.0039	0.0003
As	0.0010	0.0003		Ni	1.39	0.01
B	0.0084	0.0004		P	0.0471	0.0008
C	3.45	0.05		Pb	0.0007	0.0003
Ca	0.0009	0.0002		S	0.0126	0.0006
Co	0.0036	0.0006		Si	1.93	0.01
Cr	1.047	0.007		Sn	0.0017	0.0005
Cu	0.322	0.003		Ti	0.0427	0.0008
Fe	90.54	0.09		V	0.121	0.001
Mg	0.048	0.001		W	0.0608	0.0009
Mn	0.730	0.007		Zr	0.0055	0.0003
Mo	0.238	0.002				

Informational Values^{3,4}

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 5 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 5 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.

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mg
1	5	0.013967	3	0.0003	4	0.00753	3	3.37	4	0.0006	3	0.0012	3	1.030	4	0.311667	3	90.44	3	0.04752
2	3	0.014067	3	0.0004	14	0.0081	3	3.37	4	0.0006	3	0.0013	3	1.040	4	0.313	3	90.47	3	0.0476
3	3	0.0153	3	0.0004	3	0.00822	1	3.38667	3	0.00075	3	0.0015	3	1.040	10	0.3130	3	90.47	3	0.04764
4	3	0.0154	3	0.0004	3	0.00823	3	3.4	3	0.00083	3	0.0016	3	1.040	3	0.319	3	90.47	3	0.04766
5	3	0.0156	3	0.0004	3	0.00825	3	3.4	3	0.00084	3	0.0027	3	1.040	3	0.319	3	90.47	3	0.04766
6	3	0.0157	3	0.0005	3	0.00825	1	3.40873	3	0.00084	3	0.0028	3	1.040	3	0.319	3	90.48	3	0.04768
7	3	0.0157	3	0.0007	3	0.00826	3	3.41	3	0.00086	10	0.0032	3	1.040	3	0.319	3	90.5	3	0.04772
8	4	0.015767	3	0.0007	3	0.00827	3	3.41	3	0.00088	3	0.0033667	3	1.040	3	0.319	3	90.5	3	0.04777
9	3	0.0158	3	0.0007	3	0.00828	3	3.41	3	0.00089	3	0.0034	3	1.040	3	0.32	3	90.51	3	0.04782
10	3	0.0158	3	0.0008	3	0.0083	3	3.42	3	0.0009	4	0.0034333	3	1.040	3	0.32	3	90.51	3	0.04786
11	3	0.0158	3	0.0008	3	0.00832	1	3.42667	3	0.00091	3	0.0037	3	1.040	3	0.32	3	90.51	3	0.04788
12	3	0.0159	3	0.0008	3	0.00833	3	3.43	3	0.00092	3	0.0037	3	1.040	3	0.32	3	90.52	3	0.048
13	3	0.0159	3	0.0008	3	0.00835	3	3.43	3	0.00093	3	0.0038	3	1.040	3	0.321	3	90.52	3	0.04802
14	3	0.0159	3	0.0009	3	0.00836	3	3.43	3	0.00094	3	0.0039	3	1.040	3	0.321	16	90.53333	3	0.04808
15	3	0.016	3	0.001	3	0.00837	3	3.43	3	0.00094	14	0.0039	10	1.040	3	0.321	16	90.5392	3	0.04811
16	3	0.016	3	0.001	3	0.00837	3	3.44	3	0.00095	3	0.004	3	1.040	3	0.321	3	90.54	3	0.0482
17	3	0.016	3	0.001	3	0.00838	3	3.44	3	0.00096	3	0.0041	3	1.040	14	0.321333	3	90.54	3	0.0482
18	4	0.0161	3	0.0011	3	0.00839	3	3.45	3	0.00097	3	0.0042	3	1.040	3	0.322	3	90.54	3	0.04821
19	3	0.0161	3	0.0012	3	0.00839	3	3.45	3	0.001	3	0.0043	3	1.040	3	0.322	3	90.55	3	0.04837
20	3	0.0161	5	0.001233	3	0.00841	3	3.45	3	0.00101	3	0.0044	3	1.047	3	0.322	3	90.55	3	0.0484
21	3	0.0162	3	0.0013	3	0.00841	3	3.46	3	0.00104	3	0.0044	14	1.05	3	0.322	3	90.55	3	0.04842
22	3	0.0162	3	0.0014	3	0.00842	3	3.46	3	0.00104	3	0.0044	3	1.05	3	0.322	3	90.56	3	0.04846
23	3	0.0163	3	0.0015	3	0.00845	1	3.46653	3	0.00105	3	0.0046	3	1.05	3	0.323	3	90.57	3	0.04846
24	3	0.0164	5	0.001767	3	0.00846	3	3.47	14	0.001067	5	0.004667	3	1.05	3	0.324	3	90.57	3	0.04848
25	14	0.0164	9	0.002	3	0.00849	3	3.47	3	0.00112	3	0.0048	3	1.05	3	0.324	3	90.57	3	0.04848
26	3	0.0164	5	0.002067	3	0.00854	3	3.48	3	0.00113	3	0.005	3	1.05	3	0.324	3	90.59		
27	3	0.0164			3	0.00859	3	3.48	3	0.00136			3	1.06	3	0.325	3	90.59		
28	3	0.0164			5	0.00862	3	3.49					3	1.06	3	0.325	14	90.6		
29	3	0.0167			4	0.01043	3	3.50667					4	1.06433	3	0.326	4	90.60667		
30	3	0.0169					3	3.52							3	0.33				
Average		0.01598		0.000777		0.00836		3.450		0.000896		0.00320		1.047		0.3216		90.537		0.0480
Std Dev		0.00032		0.000057		0.00023		0.038		0.000076		0.00014		0.013		0.0053		0.037		0.0010
H		0.0012		0.00036		0.00089		0.023		0.00038		0.00060		0.011		0.0054		0.23		0.0020
U ₁		0.0012		0.00036		0.00092		0.044		0.00039		0.00062		0.017		0.0075		0.23		0.0022
t-statistic		2.05		2.06		2.05		2.05		2.06		2.06		2.05		2.05		2.05		2.06
U ₂		0.0025		0.00075		0.0019		0.089		0.00079		0.0013		0.034		0.015		0.47		0.0046
U ₃		0.00046		0.00015		0.00035		0.016		0.00015		0.00024		0.0064		0.0028		0.087		0.0091
Certified		0.0160		0.0010		0.0084		3.45		0.0009		0.0036		1.047		0.322		90.54		0.048
Uncertainty		0.0005		0.0003		0.0004		0.05		0.0002		0.0006		0.007		0.003		0.09		0.001
Tolerance		0.0025		0.0009		0.0019		0.15		0.0008		0.0018		0.021		0.015		0.47		0.003

Analysis	*	Mn	*	Mo	*	Nb	*	Ni	*	P	*	Pb	*	S	*	Si	*	Sn	*	Ti
1	3	0.726	4	0.231233	3	0.0037	4	1.31233	5	0.038633	5	0.0001533	3	0.011	3	1.92	3	0.0006	5	0.04157
2	3	0.726	10	0.235	3	0.0037	10	1.32	10	0.044	5	0.0001667	1	0.01103	3	1.92	3	0.0009	3	0.042
3	3	0.727	3	0.236	3	0.0037	4	1.34643	3	0.046	3	0.0002	3	0.0116	3	1.92	3	0.001	3	0.0424
4	3	0.727	3	0.237	3	0.0037	3	1.35	3	0.046	9	0.0002	3	0.012	3	1.92	5	0.001	3	0.0424
5	3	0.728	3	0.237	3	0.0037	4	1.35333	3	0.0462	5	0.0002	3	0.012	3	1.92	5	0.001033	10	0.0425
6	3	0.728	3	0.237	3	0.0038	3	1.35967	3	0.0464	3	0.0003	3	0.012	3	1.92	3	0.0011	3	0.0425
7	3	0.728	3	0.237	3	0.0038	3	1.38	3	0.0464	3	0.0004	3	0.0121	14	1.926667	10	0.0012	3	0.0426
8	3	0.729	3	0.237	3	0.0038	3	1.38	3	0.0465	3	0.0005	3	0.0122	3	1.93	3	0.0012	3	0.0426
9	3	0.729	3	0.237	3	0.0038	3	1.38	3	0.0468	3	0.0006	3	0.0123	3	1.93	3	0.0014	3	0.0426
10	3	0.73	3	0.237	4	0.00387	3	1.38	3	0.0469	3	0.0006	3	0.0123	3	1.93	3	0.0014	14	0.04263
11	3	0.73	3	0.237	14	0.00387	14	1.38667	3	0.047	3	0.0007	3	0.0124	3	1.93	3	0.0014	3	0.0427
12	3	0.73	3	0.237	3	0.0039	3	1.39	3	0.047	3	0.0007	3	0.0125	3	1.93	3	0.0015	3	0.0427
13	3	0.73	3	0.238	3	0.0039	3	1.39	3	0.047	3	0.0007	3	0.0126	3	1.93	3	0.0015	3	0.0427
14	3	0.73	3	0.238	3	0.0039	3	1.39	3	0.0471	3	0.0007	3	0.0126	3	1.93	3	0.0015	3	0.0427
15	3	0.731	3	0.238	3	0.0039	3	1.39	14	0.0472	3	0.0008	1	0.0126	3	1.93	9	0.001667	3	0.0427
16	3	0.731	14	0.238	3	0.0039	3	1.39	3	0.0473	10	0.0008	1	0.01267	3	1.93	3	0.0018	3	0.0427
17	3	0.731	3	0.238	3	0.0039	3	1.4	3	0.0474	3	0.0008	3	0.0127	3	1.93	3	0.0018	4	0.04273
18	3	0.732	3	0.238	3	0.004	3	1.4	3	0.0476	3	0.0008	3	0.0128	3	1.93	3	0.0019	3	0.0428
19	10	0.732	3	0.238	3	0.004	3	1.4	3	0.0478	3	0.0008	3	0.0129	3	1.93	3	0.0019	3	0.0428
20	3	0.732	3	0.238	3	0.004	3	1.4	3	0.0478	3	0.0008	3	0.0129	3	1.93	3	0.0021	3	0.0428
21	3	0.733	3	0.238	3	0.004	3	1.4	3	0.0478	3	0.0009	3	0.0129	3	1.93	3	0.0021	3	0.0428
22	3	0.733	3	0.238667	3	0.004	3	1.4	3	0.0478	3	0.001	10	0.013	3	1.94	3	0.0021	3	0.0429
23	3	0.733	4	0.239	3	0.004	3	1.4	3	0.0479	3	0.001	3	0.013	3	1.94	3	0.0021	3	0.0429
24	3	0.733	3	0.239	3	0.004	3	1.4	3	0.048	3	0.001	3	0.013	3	1.94	3	0.0021	3	0.0429
25	3	0.734	3	0.239	3	0.004	3	1.4	3	0.0481	3	0.001	3	0.0131	3	1.94	3	0.0022	3	0.0429
26	3	0.734	3	0.239	3	0.0041	3	1.4	3	0.0483	3	0.0011	3	0.0132	3	1.94	3	0.0022	3	0.043
27	4	0.734667	3	0.239	3	0.0042	3	1.41	3	0.0484	3	0.0011	3	0.0132	17	1.948833	3	0.0022	3	0.043
28			3	0.24			3	1.41	3	0.0488	3	0.0011	3	0.0137			3	0.0024	3	0.043
29			3	0.24			3	1.43	4	0.049367	3	0.0012	3	0.0139			5	0.002467	3	0.043
30			3	0.24			3	1.44	3	0.0496	3	0.0012	3	0.0143			3	0.0025	3	0.043
31									4	0.051033										
Average		0.730		0.2379		0.00389		1.383		0.04715		0.000717		0.01265		1.929		0.001384		0.04271
Std Dev		0.015		0.0039		0.00015		0.018		0.00089		0.000058		0.00025		0.027		0.000078		0.00081
H		0.009		0.0046		0.00065		0.013		0.001968		0.00035		0.0011		0.016		0.00044		0.00188
U ₁		0.017		0.0060		0.00067		0.022		0.0022		0.00035		0.0011		0.032		0.00045		0.0020
t-statistic		2.06		2.05		2.06		2.05		2.04		2.05		2.05		2.06		2.05		2.05
U ₂		0.035		0.012		0.0014		0.045		0.0044		0.00073		0.0022		0.065		0.00091		0.0042
U ₃		0.0067		0.0022		0.00026		0.0082		0.00079		0.00013		0.00041		0.012		0.00017		0.00076
Certified		0.730		0.238		0.0039		1.39		0.0471		0.0007		0.0126		1.93		0.0017		0.0427
Uncertainty		0.007		0.002		0.0003		0.01		0.0008		0.0003		0.0006		0.01		0.0005		0.0008
Tolerance		0.035		0.012		0.0014		0.03		0.0044		0.0006		0.0018		0.06		0.0015		0.0042

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* Code for method

Certified values listed as weight percent

Analysis	*	V	*	W	*	Zr
1	3	0.115	3	0.0596	14	0.00293
2	5	0.118667	3	0.0597	5	0.0036
3	3	0.12	3	0.0597	3	0.0053
4	3	0.12	3	0.0598	3	0.0054
5	3	0.12	3	0.0598	3	0.0054
6	10	0.12	3	0.0599	3	0.0055
7	3	0.121	10	0.06	3	0.0055
8	3	0.121	3	0.0601	3	0.0055
9	3	0.121	3	0.0601	3	0.0055
10	3	0.121	3	0.0603	3	0.0055
11	3	0.121	3	0.0603	3	0.0055
12	3	0.121	3	0.0604	3	0.0055
13	3	0.121	3	0.0604	3	0.0055
14	3	0.121	3	0.0606	3	0.0055
15	3	0.121	3	0.0606	3	0.0055
16	3	0.122	3	0.0607	3	0.0055
17	3	0.122	14	0.0608	3	0.0056
18	3	0.122	4	0.0608	3	0.0056
19	3	0.122	3	0.0609	3	0.0056
20	3	0.122	3	0.061	3	0.0056
21	3	0.122	3	0.061	3	0.0056
22	3	0.122	3	0.0611	3	0.0056
23	3	0.122	3	0.0612	3	0.0056
24	3	0.122	3	0.0613	3	0.0057
25	3	0.122	3	0.0613	3	0.0057
26	3	0.122	3	0.0613	3	0.0057
27	4	0.1223	3	0.0614	3	0.0058
28	14	0.123	3	0.0614		
29	3	0.123	4	0.063		
30	3	0.123	3	0.063333		
31	4	0.127333	5	0.063933		
Average		0.1211		0.0608		0.00546
Std Dev		0.0022		0.0011		0.00016
H		0.0032		0.0022		0.00075
U ₁		0.0038		0.0025		0.00076
t-statistic		2.04		2.04		2.06
U ₂		0.0079		0.0051		0.0016
U ₃		0.0014		0.00092		0.00030
Certified		0.121		0.0608		0.0055
Uncertainty		0.001		0.0009		0.0003
Tolerance		0.008		0.0051		0.0016

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* Code for method

Informational values listed as weight percent

Analysis	*	Sb
1	10	0.2
Average		0.20
Std Dev		2.18
H		0.00
U ₁		2.18
t-statistic		12.71
U ₂		27.77
U ₃		27.77
Informational		(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 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 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 285BD 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 285BD-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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14603 Benfer Road
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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

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