

Brammer Standard Company, Inc.

Certificate of Analysis

BS 285CA

Certified Reference Material for Chill Cast Iron

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.019	0.001		Mo	0.009
As	0.0022	0.0003		Ni	0.05
C	3.30	0.08		P	0.004
Ca	0.0018	0.0004		S	0.002
Cr	1.00	0.06		Si	0.04
Cu	0.31	0.02		Ti	0.004
Fe	90.89	0.08		V	0.007
Mg	0.032	0.001		W	0.005
Mn	0.701	0.009			

	Reference Value ¹	Estimate of Uncertainty ²	Reference Values^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
B	0.007	0.002		Pb	0.0005
Co	0.005	0.001		Sb	0.009
N	<0.05			Sn	0.0009
Nb	0.004	0.002		Ta	<0.005
O	<0.05			Zr	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 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 Reference values 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	*	C	*	Ca	*	Cr	*	Cu	*	Fe	*	Mg	*	Mn	*	Mo
1	3	0.019	5	0.001933	1	3.223333	4	0.0013	4	0.976667	3	0.291	4	90.776	3	0.032	4	0.687	4	0.1676667
2	3	0.019	3	0.002	1	3.228667	14	0.0014	8	0.98	8	0.291	16	[90.7766]	3	0.032	3	0.688	7	0.1766667
3	3	0.019	4	0.0021	1	3.256667	11	0.0014	3	0.98	3	0.292	16	[90.79]	3	0.032	3	0.69	3	0.178
4	3	0.02	3	0.0021	1	3.258	11	0.0015	10	0.98	3	0.292	4	90.826007	3	0.032	3	0.69	3	0.18
5	3	0.019	3	0.0022	3	3.27	11	0.0015	11	0.987	3	0.294	16	[90.83]	3	0.032	3	0.692	4	0.183
6			3	0.0022	1	3.288333	11	0.0016	11	0.991	3	0.295	4	90.843333			3	0.692	3	0.184
7			5	0.002233	3	3.29	4	0.0016333	11	0.993	3	0.296	16	[90.86]			3	0.692	10	0.185
8			15	0.002263	3	3.3	11	0.0017	4	0.993667	4	0.3001	16	[90.86]			4	0.69483333	14	0.188
9			3	0.0023	1	3.30	11	0.0017	3	0.994	10	0.300333	4	90.87			3	0.69766667	3	0.1896667
10			3	0.0023	3	3.3	3	0.0018	3	0.996	4	0.301333	16	[90.88]			11	0.698	3	0.19
11			4	0.0023	3	3.3	4	0.0020333	11	0.996	4	0.303633	16	[90.88]			8	0.699	3	0.190
12			5	0.002347	1	3.30	3	0.0021	3	0.997	4	0.304	2	90.8892			14	0.699	8	0.190
13			9	0.0024	11	3.3	3	0.0021	11	0.997	4	0.304033	16	[90.9]			4	0.69910333	4	0.1901333
14			4	0.002667	1	3.308	3	0.0021	3	0.997	3	0.305	16	[90.90433]			4	0.70006667	4	0.1903
15					11	3.31	3	0.0022	11	0.998	4	0.306333	16	[90.94]			4	0.702	11	0.191
16					11	3.31	4	0.0022	3	0.999	3	0.307	16	[90.94]			11	0.703	11	0.191
17					11	3.31			3	1	10	0.31	16	[90.94]			4	0.70343333	11	0.191
18					3	3.31			4	1.0000	3	0.31	16	[90.9433]			11	0.704	3	0.191
19					11	3.32			4	1.005033	11	0.31	16	[90.95]			11	0.705	11	0.191
20					1	3.339067			4	1.006333	4	0.311	13	90.954333			11	0.706	4	0.1913333
21					1	3.359233			4	1.0089	11	0.311	16	[90.96]			4	0.7063	4	0.191433
22					11	3.36			13	1.01	11	0.311	3	90.99333			11	0.707	3	0.192
23					1	3.366667			3	1.01	11	0.311					10	0.708333	11	0.192
24					1	3.382267			14	1.01	4	0.311667					4	0.708667	11	0.192
25									4	1.012	11	0.312					10	0.71	10	0.192
26									4	1.022833	11	0.312					4	0.711	4	0.1923
27									4	1.0243	5	0.314667					3	0.718	7	0.193
28									3	1.043333	7	0.319667					3	0.72	3	0.194
29									4	1.047	14	0.323667							4	0.199433
30									10	1.063333	4	0.329667							4	0.203667
31																			5	0.207
Average		0.01920		0.002219		3.303760		0.001831		1.003947		0.3061		90.890		0.0320		0.701122		0.1897
Std Dev		0.00090		0.000088		0.000065		0.000058		0.000058		0.0024		0.024		0.0014		0.000060		0.0020
H		0.001447		0.00058		0.022		0.00054		0.011		0.0057		0.18		0.001831		0.0089		0.0044
U ₁		0.0017		0.00059		0.022		0.00054		0.011		0.0062		0.18		0.0023		0.0089		0.0049
t-statistic		2.78		2.16		2.07		2.13		2.05		2.05		2.08		2.78		2.05		2.04
U ₂		0.0047		0.0013		0.045		0.0012		0.022		0.013		0.38		0.0065		0.018		0.010
U ₃		0.0021		0.00034		0.0091		0.00029		0.0041		0.0023		0.081		0.0029		0.0034		0.0018
Certified		0.019		0.0022		3.30		0.0018		1.00		0.31		90.89		0.032		0.701		0.190
Uncertainty		0.001		0.0003		0.08		0.0004		0.06		0.02		0.08		0.001		0.009		0.009
Tolerance		0.003		0.0013		0.24		0.0012		0.18		0.06		0.38		0.003		0.027		0.027

Analysis	*	Ni	*	P	*	S	*	Si	*	Ti	*	V	*	W
1	10	1.22	5	0.0397	1	0.004	3	1.87	4	0.038733	8	0.119	3	0.0392667
2	3	1.2366667	10	0.039867	1	0.005	4	1.8993333	3	0.0405	4	0.1262	4	0.0448
3	4	1.245	4	0.041433	1	0.005033	3	1.91	3	0.042	3	0.13	3	0.045
4	3	1.25	7	0.042767	10	0.006	6	1.9175	4	0.042033	4	0.13	11	0.0463
5	3	1.25	4	0.0439	1	0.006463	4	1.9299	4	0.0421	10	0.13	11	0.0464
6	3	1.25	4	0.044333	14	0.006533	6	1.93	3	0.0438	13	0.13	11	0.0466
7	3	1.25	3	0.0445	1	0.007467	4	1.9344333	10	0.0438	4	0.130033	11	0.0469
8	3	1.26	3	0.045	1	0.00754	3	1.94	4	0.043867	4	0.1307	4	0.0472667
9	3	1.26	3	0.046	3	0.0076	11	1.94	3	0.0439	4	0.1308	11	0.0477
10	4	1.2673333	3	0.0461	3	0.0078	11	1.94	3	0.0439	3	0.131	3	0.0477
11	7	1.27	11	0.0462	3	0.0078	6	1.9411667	3	0.044	4	0.131067	14	0.0477667
12	3	1.27	11	0.0463	3	0.0078	4	1.9433333	10	0.044	14	0.132667	11	0.0478
13	4	1.2701667	11	0.0464	3	0.008	4	1.9466667	3	0.0441	3	0.133	4	0.048
14	4	1.2707	3	0.0465	1	0.0083	4	1.948	11	0.0444	3	0.133	3	0.0481
15	14	1.2766667	11	0.0466	1	0.0083	14	1.95	4	0.044433	3	0.133	4	0.0483333
16	10	1.28	11	0.0468	3	0.0084	11	1.95	11	0.0445	4	0.1337	3	0.0484
17	3	1.28	10	0.047	11	0.0088	3	1.95	11	0.0446	11	0.134	3	0.0484
18	4	1.2800333	3	0.047	1	0.008967	11	1.95	4	0.044667	3	0.134	4	0.0486
19	4	1.2801	14	0.047667	1	0.009	11	1.95	3	0.045	11	0.134	3	0.0486
20	4	1.2816667	11	0.0477	11	0.0091	3	1.95	14	0.045	11	0.134	3	0.0489
21	4	1.281667	6	0.0494	11	0.0092	3	1.95	11	0.045	3	0.134	10	0.049
22	8	1.29	4	0.049433	1	0.009267	3	1.95	11	0.045	3	0.135	4	0.050233
23	4	1.296667	4	0.049783	1	0.0093	4	1.950133	4	0.045033	11	0.135	4	0.052633
24	4	1.299833	4	0.049967	11	0.0095	6	1.950333	11	0.0451	11	0.135	4	0.054267
25	11	1.3	3	0.05	11	0.0102	3	1.96	3	0.0452	11	0.135	3	0.055
26	11	1.3	4	0.0501	1	0.011367	3	1.96	4	0.046333	3	0.135333	5	0.061133
27	11	1.3	3	0.0528			11	1.96	4	0.0468	4	0.136	4	0.067333
28	11	1.3	3	0.053			6	1.967	4	0.047033	4	0.137		
29	11	1.3	4	0.0547			4	1.97			5	0.142667		
30	11	1.3									10	0.147667		
Average		1.273883		0.046929		0.007951		1.941648		0.044101		0.1330		0.049275
Std Dev		0.000058		0.000059		0.000062		0.000059		0.000060		0.0017		0.000061
H		0.012		0.0022		0.00098		0.016		0.0021		0.0037		0.0022
U ₁		0.012		0.0022		0.00098		0.016		0.0021		0.0041		0.0022
t-statistic		2.05		2.05		2.06		2.05		2.05		2.05		2.06
U ₂		0.025		0.0045		0.0020		0.032		0.0044		0.0083		0.0046
U ₃		0.0046		0.00084		0.00040		0.0060		0.00083		0.0015		0.00089
Certified		1.27		0.047		0.008		1.94		0.044		0.133		0.049
Uncertainty		0.05		0.004		0.002		0.04		0.004		0.007		0.005
Tolerance		0.15		0.012		0.006		0.12		0.012		0.021		0.015

Analysis	*	B	*	Co	*	N	*	Nb	*	O	*	Pb	*	Sb	*	Sn	*	Ta	*	Zr
1	14	0.0011	3	0.004	2	0.007353	5	0.00093	2	0.001653	5	0.000047	11	0.0018	5	0.0005633	5	0.00005	4	0.0002
2	3	0.0035	5	0.004033			5	0.0010			5	0.000076	11	0.0031	3	0.0006	5	0.000053	5	0.0003967
3	4	0.0043667	3	0.0041			5	0.00104			5	0.0001	11	0.0035	3	0.0006			5	0.0005133
4	4	0.005	3	0.0041			11	0.0037			3	0.0002	11	0.0061	5	0.0006567			14	0.002
5	4	0.0075333	3	0.0042			11	0.0038			3	0.0005	3	0.009	3	0.0007			4	0.0042667
6	3	0.0076	3	0.0044			11	0.0038			11	0.0007	3	0.0093	3	0.0007			3	0.0049
7	3	0.0076	11	0.0045			11	0.0039			9	0.0008	3	0.0114	3	0.0008			3	0.0049
8	3	0.0076	11	0.0045			11	0.004			11	0.0008	4	0.0117667	3	0.0011			3	0.0049
9	3	0.0076	4	0.004533			11	0.0041			11	0.0009	9	0.0127333	5	0.0014			3	0.005
10	3	0.0077	11	0.0047			3	0.0046			11	0.0009	4	0.0127667	4	0.0016667			3	0.005
11	3	0.0078	11	0.0047			3	0.005			4	0.001	4	0.0128667	11	0.0018			3	0.005
12	4	0.0078333	3	0.0047			3	0.005			11	0.0012	4	0.0129667	11	0.0019			4	0.0059667
13	4	0.0079667	10	0.005			3	0.005			4	0.001233	4	0.0157	4	0.0019667			4	0.0060333
14	4	0.0080333	4	0.00511			3	0.0053					3	0.017	10	0.002			11	0.0061
15	11	0.0081	5	0.005167			3	0.0054					3	0.0171	11	0.0021			11	0.0066
16	11	0.0081	11	0.0052			3	0.0056					10	0.018	11	0.0026			11	0.0068
17	11	0.0081	3	0.0054			14	0.0058333					4	0.0203333	11	0.0031			11	0.0069
18	11	0.0081	11	0.0054			4	0.0102					3	0.0207					11	0.007
19	11	0.0082	8	0.006									3	0.0221					11	0.007
20	4	0.0083933	4	0.0061									5	0.0221333						
21	11	0.0084	14	0.006733									5	0.022567						
22	5	0.008467	4	0.008033									11	0.024						
23	7	0.008837	17	0.009547									11	0.0247						
24	4	0.0093	5	0.009627									5	0.0252						
Average		0.00737		0.005408		0.00735		0.004301		0.00165		0.000650		0.014868		0.001427		0.0000513		0.004709
Std Dev		0.00016		0.000065		0.00068		0.000075		0.00015		0.000088		0.000065		0.000077		0.0000073		0.000073
H		0.00095		0.00083		0.0009		0.00076		0.00052		0.00036		0.0013		0.00049		0.00016		0.00078
U ₁		0.00096		0.00083		0.0012		0.00076		0.00054		0.00037		0.0013		0.00049		0.00016		0.00079
t-statistic		2.07		2.07		12.71		2.11		12.71		2.18		2.07		2.12		12.71		2.10
U ₂		0.0020		0.0017		0.015		0.0016		0.0068		0.00082		0.0027		0.0010		0.0020		0.0017
U ₃		0.00041		0.00035		0.015		0.00038		0.0068		0.00023		0.00055		0.00025		0.0014		0.00038
Reference		0.007		0.005		<0.05		0.004		<0.05		0.0007		0.015		0.0014		<0.005		0.005
Uncertainty		0.002		0.001				0.002				0.0005		0.009		0.0009				0.002
Tolerance		0.006		0.003				0.003				0.0006		0.014		0.0013				0.004

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 | AAS |
| 6 | Gravimetric | 12 | GD Mass Spectrometry | | |

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

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.

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
NSL Analytical	Cleveland, OH	ANAB	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Shiva Analyticals Private Limited	Hoskote, Bangalore	NABL	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Vitkovice Testing Center	Hulvaky, Ostrava	Czech Accreditation Institute	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Laboratory Testing, Inc.	Hatfield, PA	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Luvak Inc.	Boylston, MA	PRI	17025
Raghavendra Spectro Metallurgical Laboratory	Karnataka, India	NABL	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025

A2LA = American Association for Laboratory Accreditation

ANAB = ANSI-ASQ National Accreditation Board

CNAS = China National Accreditation Service

NABL = National Accreditation Board for Testing and Calibration Laboratories

PCA = Polish Center for Accreditation

PRI = Performance Review Institute

Analysis: Chemical analyses were made on solid pieces and chips prepared by an end mill 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: 11XC2R, 11XC4S, 11XC5T; AR 303, 307, 310, 868, 881, 882, 892; BAS 317, 464/1, 535; BS C11A, CI4, 27, 55H, 72B, 284D, 285, 285AA, 285BB, 285BF, 285BJ, 285CC, 286C, 286CA; CKD 166, 234, 238, 244, 247; CZ 2019A; 02033 1A, 02033 13B, 02033 6C; ECRM 190-1, 47-1, 480-1; IARM FeDP1080; IPT 12A, 75A, 97; LECO 501-024, 501-677, 502-916, 502-919; SPL 6A, 7A, 13A; SRM 4K, 5L, 13F, 16F, 82B, 160B, 342C, 361, 363, 365, 891.

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 C14, 27, 284D, 285, 285AA, 285BB, 285BF, 285BJ, 286C; CKD 244.

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 285CA 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 33mm in diameter and 30mm 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.

Note: Shrinkage cavities may appear in the horizontal center of some discs. These cavities are normal and will not affect the certified portions of the disc.

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.

Caution: CRM contains significant insoluble soft metal inclusions. Surface smearing may occur. Spark atomic emission spectrometers may require extended preburns to compensate.

Certificate Number: The unique identification number for this certificate of analysis is 285CA-082523. 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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Fax: (281) 440-4432

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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 17025:2017 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 35:2017 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 August 25, 2023.

Beau R. Brammer

President