Brammer Standard Company, Inc.

Certificate of Analysis

BS 291EB

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	**0.046**	0.001	**Nb**	**0.0032**	0.0003
B	**0.0055**	0.0003	**Ni**	**0.099**	0.001
C	**3.25**	0.04	**P**	**0.0189**	0.0006
Ca	**0.0009**	0.0002	**S**	**0.012**	0.001
Cr	**0.015**	0.001	**Si**	**2.09**	0.03
Cu	**0.234**	0.005	**Sn**	**0.0480**	0.0009
Fe	**93.6**	0.2	**Ti**	**0.0159**	0.0005
Mg	**0.040**	0.001	**V**	**0.0082**	0.0004
Mn	**0.477**	0.004	**Zr**	**0.0022**	0.0003
Mo	**0.0075**	0.0004			

Informational Values[3,4]

As (0.0007) Co (0.0040) Pb (0.0004) Sb (0.01) W (0.0031)

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

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

Analysis	*	Al	*	B	*	C	*	Ca	*	Cr	*	Cu	*	Fe	*	Mg	*	Mn	*	Mo
1	3	0.0434	3	0.00519	3	3.18	3	0.0006	3	0.0116	10	0.2166667	10	93.25	3	0.03955	4	0.4458667	3	0.0064
2	3	0.0435	3	0.00529	3	3.2	3	0.00062	3	0.0119	4	0.225	4	93.4	3	0.03958	3	0.464	3	0.0068
3	3	0.0443	3	0.00529	3	3.2	3	0.00068	3	0.0123	3	0.227	14	93.433333	3	0.03967	3	0.467	3	0.0068
4	3	0.045	3	0.00533	3	3.2	3	0.00078	3	0.0125	3	0.2283333	4	93.443233	3	0.03974	4	0.4673333	3	0.0069
5	3	0.0455	14	0.0053333	3	3.21	4	0.0008333	10	0.013	4	0.2296	4	93.58	3	0.03975	3	0.47	3	0.0069
6	3	0.0456	3	0.00534	3	3.22	3	0.00089	3	0.014	10	0.23	3	93.6	3	0.03992	3	0.4733333	4	0.0071333
7	3	0.0456667	3	0.00535	3	3.22	14	0.0009	3	0.0141	3	0.231	16	93.63	3	0.04008	3	0.474	3	0.0073
8	3	0.0457	4	0.0053667	3	3.22	3	0.00092	3	0.0141	3	0.233	16	93.69	3	0.04009	4	0.4742333	3	0.0073
9	10	0.046	3	0.00537	3	3.23	3	0.00094	4	0.01437	3	0.233	16	93.7	3	0.04013	3	0.475	3	0.0074
10	3	0.046	3	0.00539	3	3.23	3	0.00094	3	0.0145	3	0.234	10	93.883333	3	0.04019	3	0.475	3	0.0074
11	3	0.0461	3	0.00539	3	3.23	3	0.00098	3	0.0148	3	0.235			3	0.04024	3	0.477	3	0.0075
12	14	0.0467	3	0.0054	3	3.24	3	0.00099	3	0.0149	3	0.235			3	0.04025	3	0.477	3	0.0075
13	3	0.0467	3	0.00541	3	3.25	3	0.00101	3	0.0149	3	0.235			3	0.04026	3	0.478	3	0.0076
14	3	0.0469	3	0.00545	3	3.26	3	0.00102	3	0.0149	3	0.235			3	0.04036	3	0.478	3	0.0076
15	3	0.0471	3	0.00545	3	3.28	3	0.00103	4	0.01507	3	0.235			3	0.04036	3	0.479	5	0.0077333
16	3	0.0471	3	0.0054667	3	3.31	3	0.00107	14	0.0151	3	0.235			3	0.04038	10	0.48	3	0.0078
17	3	0.0473	3	0.00547	1	3.3266667	3	0.00107	4	0.01523	3	0.236			3	0.04038	3	0.48	3	0.0081
18	3	0.0478	3	0.00547	3	3.41	3	0.00108	3	0.01533	3	0.236					3	0.481	3	0.0082
19	4	0.0479	3	0.0055	1	3.4585667	4	0.0011	3	0.0156	3	0.239					3	0.481	3	0.0083333
20	3	0.0481	3	0.00559			4	0.0012	3	0.016	4	0.2391667					3	0.481	14	0.0083667
21	5	0.048433	4	0.0058			3	0.00152	5	0.0162	3	0.24					14	0.481667	4	0.0088
22	3	0.0489	4	0.005967					3	0.0175	3	0.24					3	0.483	10	0.009
23			5	0.006267					3	0.0182	3	0.245					3	0.488		
24									3	0.0206							3	0.489		
25																	10	0.49167		
26																	4	0.499667		
Average		0.0462		0.00549		3.250		0.000949		0.01446		0.2335		93.583		0.04005		0.4769		0.00746
Std Dev		0.0010		0.00016		0.077		0.000077		0.00035		0.0045		0.034		0.00097		0.0064		0.00023
H		0.0019		0.00074		0.022		0.00038		0.0011		0.0045		0.24		0.0018		0.007		0.00084
U_1		0.0022		0.00076		0.080		0.00039		0.0012		0.0064		0.24		0.0021		0.0093		0.00088
t-statistic		2.08		2.07		2.10		2.09		2.07		2.07		2.26		2.12		2.06		2.08
U_2		0.0046		0.0016		0.17		0.00082		0.0024		0.013		0.54		0.0044		0.019		0.0018
U_3		0.0010		0.00033		0.038		0.00018		0.00050		0.0028		0.17		0.0011		0.0038		0.00039
Certified		**0.046**		**0.0055**		**3.25**		**0.0009**		**0.015**		**0.234**		**93.6**		**0.040**		**0.477**		**0.0075**
Uncertainty		0.001		0.0003		0.04		0.0002		0.001		0.005		0.2		0.001		0.004		0.0004
Tolerance		0.005		0.0016		0.17		0.0008		0.003		0.015		0.5		0.004		0.019		0.0018

Analysis	*	Nb	*	Ni	*	P	*	S	*	Si	*	Sn	*	Ti	*	V	*	Zr
1	5	0.0003833	10	0.0917333	4	0.0176333	3	0.0101	3	2.04333	3	0.044	3	0.0145	14	0.0077333	10	0.001
2	10	0.001	3	0.0951	3	0.0176667	3	0.0102	4	2.04967	4	0.0462333	3	0.0153	4	0.0077333	5	0.0010467
3	3	0.0025	4	0.0959667	3	0.0178	3	0.0104	3	2.05	3	0.0464333	3	0.0155	3	0.0079	3	0.0018
4	4	0.0026667	3	0.096	3	0.0181	3	0.0105	3	2.06333	3	0.0469	3	0.0156	3	0.008	4	0.0018
5	3	0.0029	3	0.0966	3	0.0182	3	0.0113	14	2.07	3	0.0474	3	0.0156	3	0.008	3	0.002
6	3	0.0029	10	0.097	3	0.0183	1	0.0116667	3	2.07	3	0.0475	3	0.0157	3	0.0081	3	0.002
7	3	0.0029	3	0.0977	3	0.0183	3	0.0117	3	2.07	3	0.0475	4	0.0158	3	0.0081	3	0.002
8	3	0.003	4	0.0978333	4	0.0184667	3	0.0118	14	2.07027	3	0.0475	3	0.0158	3	0.0082	3	0.0021
9	3	0.0031	3	0.0981	10	0.0185	3	0.012	3	2.08	3	0.0477	3	0.0158	3	0.0082	3	0.0021
10	3	0.0031	4	0.0983333	3	0.0185	3	0.012	3	2.08	3	0.0478	3	0.0158	3	0.0082	3	0.0022
11	3	0.0032	3	0.0985	5	0.0186667	3	0.0123	3	2.09	3	0.0478	3	0.0158	3	0.0082	3	0.0022
12	3	0.0032	3	0.0987	3	0.0187	3	0.0123	3	2.09	9	0.0479	14	0.0158333	3	0.0082	3	0.0022
13	3	0.0033	3	0.0987	3	0.0187	3	0.0123333	4	2.1	3	0.0479	3	0.0159	3	0.0082	3	0.0022
14	3	0.0035	14	0.0989667	14	0.0188333	3	0.0127	3	2.10	3	0.0482	3	0.0159	3	0.0082	3	0.0023
15	3	0.0036	3	0.099	3	0.0189	1	0.0127667	3	2.1	3	0.0483	3	0.016	3	0.0083	3	0.0023
16	3	0.0037	3	0.099	3	0.0189	3	0.0128	3	2.11	3	0.0484	3	0.016	3	0.0083	3	0.0023
17	3	0.0038	3	0.0991	3	0.019	10	0.013	3	2.11	3	0.0484	3	0.016	3	0.0083	3	0.0024
18	3	0.0039	3	0.0993	3	0.019	3	0.0134	3	2.11	3	0.0484	10	0.016	3	0.0083	3	0.0026
19	3	0.0039	3	0.0993	3	0.0191	3	0.0138	3	2.11	3	0.0485	3	0.016	4	0.0085	3	0.0026
20			3	0.0993	3	0.0191	3	0.014	3	2.12	3	0.0487	3	0.016	3	0.0085	3	0.0027
21			3	0.0994	3	0.0196	3	0.0144	3	2.12	10	0.049	4	0.0161	5	0.008533		
22			3	0.1008	4	0.0198	1	0.014733	3	2.13	3	0.049	3	0.0162	5	0.008567		
23			3	0.101	3	0.0199			3	2.15	4	0.0503	4	0.016233	10	0.0087		
24			3	0.102	10	0.020					4	0.050467	3	0.0165	10	0.0090		
25			3	0.103333	3	0.02					10	0.052433	5	0.017367				
26			5	0.1133														
Average		0.0032		0.0991		0.0189		0.01212		2.070		0.0480		0.01585		0.00820		0.00222
Std Dev		0.00018		0.0020		0.00043		0.00029		0.016		0.0010		0.00036		0.00025		0.00016
H		0.0006		0.0028		0.001271		0.0010		0.016		0.0020		0.001174		0.00088		0.00052
U_1		0.00063		0.0035		0.0013		0.0011		0.023		0.0022		0.0012		0.00092		0.00054
t-statistic		2.10		2.06		2.06		2.08		2.07		2.06		2.06		2.07		2.09
U_2		0.0013		0.0072		0.0028		0.0023		0.048		0.0046		0.0025		0.0019		0.0011
U_3		0.0003		0.0014		0.00055		0.00048		0.010		0.00092		0.00051		0.00039		0.00025
Certified		**0.0032**		**0.099**		**0.0189**		**0.012**		**2.09**		**0.0480**		**0.0159**		**0.0082**		**0.0022**
Uncertainty		0.0003		0.001		0.0006		0.001		0.03		0.0009		0.0005		0.0004		0.0003
Tolerance		0.0013		0.007		0.0028		0.003		0.09		0.0027		0.0025		0.0019		0.0011

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

Analysis	*	As	*	Co	*	Pb	*	Sb	*	W
1	3	0.0001	3	0.0018	5	0.0001	10	0.0120	5	0.00057
2	3	0.0001	3	0.0019	5	0.0001233			3	0.0006
3	3	0.0001	3	0.0021	4	0.0001333			5	0.00103
4	3	0.0002	3	0.0023	9	0.0002			4	0.00193
5	3	0.0002	3	0.0023	3	0.0002			4	0.00243
6	3	0.0002	3	0.0029667	5	0.0002			10	0.0025
7	3	0.0002	14	0.0029667	3	0.0004			3	0.0025
8	3	0.0003	4	0.003	3	0.0004			3	0.0027
9	3	0.0003	10	0.0033	3	0.0004			3	0.0029
10	3	0.0003	3	0.0034	3	0.0004			3	0.003
11	3	0.0003	5	0.0036667	3	0.0004			3	0.0031
12	3	0.0003	3	0.0039	3	0.0004			3	0.0035
13	3	0.0003	3	0.0039	3	0.0005			3	0.0035
14	3	0.0003	4	0.0041333	3	0.0005			3	0.0035
15	3	0.0004	5	0.0042333	3	0.0006			3	0.0036
16	5	0.0007467	3	0.0048	10	0.0006			3	0.0036
17	5	0.0018333	3	0.0049	3	0.0006			3	0.0039
18	5	0.0021	3	0.0051	3	0.0006			3	0.0041
19	9	0.0024	3	0.0053	3	0.0006			3	0.0041
20	10	0.0028	3	0.0056	3	0.0006			3	0.0048
21			3	0.0063	3	0.0007			3	0.005
22			3	0.0064	3	0.0007			3	0.0059
23			3	0.0067	3	0.0008				
Average		0.00067		0.004		0.00044		0.01		0.003
Std Dev		0.00079		0.0014		0.00032		0.28		0.010
H		0.00034		0.001		0.00030		0.000958		0.0006
U_1		0.00086		0.014		0.00044		0.28		0.010
t-statistic		2.09		2.07		2.07		12.71		2.08
U_2		0.0018		0.029		0.00091		3.53		0.021
U_3		0.00040		0.00610		0.00019		3.53		0.0045
Informational		(0.0007)		(0.0040)		(0.0004)		(0.01)		(0.0031)

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 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
NSL Analytical	Cleveland, OH	ANAB	17025
Exova	Santa Fe Spring, CA	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
Luvak Inc.	Boylston, MA	PRI	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	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 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: 11XC1N, 11XC4Q, 11XC6U, 11XSG1A; AR 306, 323, 673; BAS 464/1; BS CI4, LF2B, 8, 29, 291, 291BB, 291DJ, 1026; CKD 234, 238, 239; CZ 20034 14A; LECO 501-024;SPL 2a, 3a, 8a, 15a; SRM 7G, 9F, 16F, 33D, 160B, 342A, 361, 362, 363, 365, 1140, 3109A, 3113, 8620C.

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 CI4, 8, 29, 291, 291BB, 291DJ; CZ 20034 14A; SRM 1140.

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 291EB 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.; Shijiazhuang, China.

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 291EB-021618. You may obtain information on revisions of certificates from the internet at.

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.
14603 Benfer Road
Houston, Texas 77069-2895 USA
Phone: (281) 440-9396 Web: www.brammerstandard.com
Fax: (281) 440-4432 Email: contact@brammerstandard.com

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 February 16, 2018.

Beau R. Brammer

President