

Brammer Standard Company, Inc.

Certificate of Analysis

BS 291FD

Certified Reference Material for **Chill-cast Iron**

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.040	0.003		Mn	0.007
B	0.014	0.001		Mo	0.001
C	3.35	0.08		Ni	0.004
Ca	0.0008	0.0003		P	0.002
Co	0.0035	0.0005		S	0.001
Cr	0.020	0.001		Si	0.04
Cu	0.208	0.005		Ti	0.002
Fe	93.1	0.1		V	0.001
Mg	0.038	0.001			

	Reference Value ¹	Estimate of Uncertainty ²	Reference Values^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
As	0.002	0.001		Sn	0.01

Informational Values^{3,5}

N (0.005)	Nb (0.002)	Pb (0.001)	Sb (0.004)	W (0.002)
Zr (0.001)				

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 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 Reference values are not certified and are provided for information only.

⁵ Values in parentheses are not certified and are provided for information only.

Trace element information values for Ba, Bi, Ce, Cl, Dy, Ga, Gd, Ge, Hf, La, Na, Nd, O, Pr, Re, Sm, Sr, Te, Th, U, Y, and Zn are shown on page 4.

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	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mg	*	Mn
1	4	0.0329	3	0.0128	3	3.23	12	0.00046	4	0.0024	3	0.0159	3	0.2	13	92.944	3	0.0376	7	0.48932
2	10	0.03406	3	0.0129	3	3.26	11	0.0006	10	0.0030	10	0.0190	4	0.20	4	92.99	3	0.0377	3	0.4900
3	3	0.037	12	0.013333	10	3.27	4	0.00077	12	0.0030	10	0.019	8	0.203	16	[93.043667]	3	0.0378	4	0.49333
4	3	0.0373	4	0.013967	10	3.2840	11	0.0008	5	0.003017	4	0.02003	4	0.20367	16	[93.0839667]	3	0.0380	3	0.494
5	10	0.038	3	0.014	3	3.31	4	0.00082	3	0.0032	3	0.0201	10	0.204	16	[93.1]	3	0.0380	11	0.495
6	14	0.0388	3	0.0141	3	3.3127	14	0.0009	4	0.003333	3	0.0202	4	0.20463	4	93.1	3	0.0380	4	0.49767
7	4	0.03903	11	0.0141	1	3.35	3	0.0011	4	0.003533	11	0.0203	3	0.2051	16	[93.14]	3	0.0380	10	0.4997
8	11	0.0396	11	0.0143	1	3.35663	3	0.0011	10	0.0036	4	0.0208	11	0.206	16	[93.17]	3	0.0380	3	0.50
9	4	0.0399	14	0.014367	1	3.36			14	0.003667	14	0.0208333	11	0.206	14	93.2	3	0.0381	10	0.50
10	3	0.0399	7	0.015267	11	3.37			4	0.003967	4	0.0209667	4	0.207	16	[93.22]	3	0.0381	11	0.500
11	11	0.0402	4	0.015267	1	3.37105			11	0.0040	3	0.0210	4	0.20767	10	93.29	3	0.0382	4	0.50017
12	3	0.041	4	0.0156	1	3.373			3	0.0041	4	0.021	10	0.20816			3	0.0383	14	0.50067
13	4	0.04143	4	0.016033	11	3.39			11	0.0045	3	0.021	4	0.20977			3	0.0383	4	0.501
14	3	0.0424			1	3.39					4	0.0211333	4	0.20987			3	0.0384	4	0.5021
15	4	0.04277			1	3.4					4	0.0213333	14	0.210			3	0.0384	4	0.50517
16	4	0.04353			1	3.40567					4	0.0216333	3	0.21			3	0.0384	8	0.51
17	5	0.04487			1	3.40667					11	0.0217	8	0.212			3	0.0384	3	0.510
18					1	3.43833							3	0.213			3	0.0384		
19													10	0.2150						
20													3	0.2177						
Average		0.0401		0.01423		3.3533		0.00082		0.003486		0.02034		0.2083		93.127		0.03811		0.5001
Std Dev		0.0011		0.00055		0.0056		0.00011		0.000088		0.00075		0.0030		0.034		0.00090		0.0045
H		0.0020		0.0013		0.022		0.00040		0.00069		0.0015		0.0046		0.18		0.0020		0.0074
U ₁		0.0023		0.0014		0.023		0.00041		0.00070		0.0017		0.0055		0.19		0.0022		0.0086
t-statistic		2.12		2.18		2.11		2.36		2.18		2.12		2.09		2.23		2.11		2.12
U ₂		0.0049		0.0030		0.048		0.0010		0.0015		0.0035		0.011		0.42		0.0046		0.018
U ₃		0.0012		0.00083		0.011		0.00034		0.00042		0.00086		0.0026		0.13		0.0011		0.0044
Certified		0.040		0.014		3.35		0.0008		0.0035		0.020		0.208		93.1		0.038		0.500
Uncertainty		0.003		0.001		0.08		0.0003		0.0005		0.001		0.005		0.1		0.001		0.007
Tolerance		0.009		0.003		0.24		0.0008		0.0015		0.004		0.015		0.4		0.005		0.021

Analysis	*	Mo	*	Ni	*	P	*	S	*	Si	*	Ti	*	V						
1	3	0.0307	10	0.090436	10	0.01834	1	0.01433	10	2.26	10	0.022118	10	0.0160						
2	3	0.0314	12	0.092333	5	0.0210	1	0.01483	3	2.2836	10	0.0237	3	0.0162						
3	3	0.0321	3	0.0931	3	0.0213	1	0.01567	10	2.2917	3	0.0239	11	0.0167						
4	10	0.0340	4	0.094833	3	0.022	11	0.0169	7	2.2925	3	0.024	4	0.01697						
5	4	0.03463	8	0.095	7	0.02253	11	0.0169	4	2.2951	10	0.024	4	0.01697						
6	4	0.03467	3	0.0951	12	0.02267	1	0.017	3	2.3014	4	0.0241333	3	0.017						
7	11	0.0348	10	0.096	4	0.02273	3	0.017	10	2.303918	4	0.0245333	11	0.017						
8	14	0.0349	11	0.0966	11	0.0228	10	0.017	6	2.316667	3	0.0246	3	0.017						
9	4	0.03497	4	0.096733	3	0.023	3	0.017	17	2.32	3	0.0247	13	0.0170						
10	11	0.0350	4	0.097067	14	0.02303	3	0.0171	4	2.3323	7	0.0250	4	0.0170						
11	4	0.035	14	0.097067	4	0.02307	13	0.01769	6	2.336667	3	0.025	14	0.01727						
12	10	0.0350	11	0.0971	4	0.02313	1	0.01783	3	2.34	11	0.0251	3	0.0173						
13	10	0.03562	3	0.099	7	0.02322	10	0.0183	4	2.347333	7	0.0251667	4	0.01733						
14	4	0.03593	4	0.1009	4	0.02327	1	0.0183	4	2.349867	4	0.0253667	4	0.01763						
15	3	0.036	4	0.100967	4	0.02347	1	0.01843	11	2.35	4	0.0257	10	0.018						
16	8	0.036	3	0.1017	11	0.0235	1	0.01856	11	2.35	11	0.026								
17	4	0.03603	4	0.102333	10	0.024	1	0.0188	3	2.35	4	0.026								
18	7	0.0363	10	0.1033	8	0.025	1	0.019	9	2.353333	14	0.0262333								
19	3	0.037	7	0.1045	10	0.0265			4	2.36	4	0.0276								
20					3	0.0265			3	2.38										
Average		0.0345		0.0966		0.023		0.01732		2.325719		0.024887		0.01695						
Std Dev		0.0010		0.0021		0.00073		0.00058		0.000071		0.000073		0.00064						
H		0.0019		0.0031		0.00157		0.0014		0.018		0.0016293		0.0014						
U ₁		0.0022		0.0038		0.0017		0.0015		0.018		0.0016		0.0015						
t-statistic		2.10		2.10		2.09		2.11		2.09		2.10		2.14						
U ₂		0.0045		0.0079		0.0036		0.0032		0.037		0.0034		0.0032						
U ₃		0.0010		0.0018		0.00081		0.00074		0.0082		0.00079		0.00084						
Certified		0.035		0.097		0.023		0.017		2.33		0.025		0.017						
Uncertainty		0.001		0.004		0.002		0.001		0.04		0.002		0.001						
Tolerance		0.005		0.012		0.006		0.003		0.12		0.006		0.003						

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* Code for method

Reference values listed as weight percent

Analysis	*	As	*	Sn
1	3	0.0009	12	0.043667
2	15	0.00097	3	0.0527
3	4	0.00107	10	0.052782
4	12	0.00113	4	0.055567
5	5	0.0012	3	0.056
6	5	0.00123	11	0.0568
7	3	0.0019	14	0.056933
8	10	0.0022	4	0.056967
9	10	0.0026	10	0.058
10	9	0.00267	3	0.0581
11			7	0.0589
12			3	0.061
13			11	0.0624
14			4	0.062967
15			4	0.063017
16			4	0.063533
17			10	0.0643
18			3	0.0653
19			5	0.0723
Average		0.00160		0.0587
Std Dev		0.00017		0.0016
H		0.00051		0.0024
U ₁		0.00054		0.0029
t-statistic		2.26		2.10
U ₂		0.0012		0.0061
U ₃		0.00038		0.0014
Reference		0.002		0.06
Uncertainty		0.001		0.01
Tolerance		0.001		0.03

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* Code for method

Informational values listed as weight percent

Analysis	*	N	*	Nb	*	Pb	*	Sb	*	W	*	Zr
1	2	0.00503	12	0.000707	5	0.0001	12	0.00273	3	0.0003	12	0.0002167
2	2	0.00511	10	0.0012	12	0.00011	3	0.0031	12	0.000737	5	0.00043
3	2	0.0061	5	0.001267	5	0.00012	3	0.0039	5	0.00091	5	0.00058
4			3	0.0013	5	0.00014	10	0.0047	5	0.001147	10	0.0008
5			5	0.001337	10	0.0008			3	0.002	3	0.0009
6			4	0.001967	11	0.0014			10	0.0036	10	0.0010
7			3	0.0027	3	0.00175			14	0.003867	3	0.001
8			10	0.0030	3	0.0019			4	0.004567	11	0.0023
9			11	0.0034	10	0.0020			11	0.036	4	0.0023667
10			3	0.0037	3	0.002			11	0.0408		
11			14	0.005567					4	0.040967		
Average		0.005		0.0024		0.0010		0.004		0.00214		0.00100
Std Dev		0.060		0.0095		0.0025		0.030		0.00011		0.00010
H		0.001		0.0006		0.0004		0.001		0.00057		0.00043
U ₁		0.060		0.0095		0.0025		0.030		0.00058		0.00044
t-statistic		4.30		2.23		2.26		3.18		2.23		2.31
U ₂		0.26		0.021		0.0056		0.094		0.0013		0.0010
U ₃		0.15		0.0064		0.0018		0.047		0.00039		0.00034
Informational		(0.005)		(0.002)		(0.001)		(0.004)		(0.002)		(0.001)

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. U₁ is the combined uncertainty from homogeneity and labs. U₂ is U₁ multiplied by the coverage factor (95 % t-statistic). U₃ is U₂ 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 U₃ 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.

BS 291FD * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ba	*	Bi	*	Ce	*	Cl	*	Dy	*	Ga	*	Gd	*	Ge	*	Hf	*	La
1	12	0.55	12	0.12	12	140	12	0.03	12	0.01	12	12	12	0.04	12	5.8	12	0.02	12	31
2	12	0.57	12	0.12	12	140	12	0.03	12	0.01	12	12	12	0.06	12	5.8	12	0.03	12	32
3	12	0.67	12	0.13	12	140	12	0.03	12	0.02	12	12	12	0.08	12	5.9	12	0.03	12	33
4					3	295														
Analysis	*	Na	*	Nd	*	O	*	Pr	*	Re	*	Sm	*	Sr	*	Te	*	Th	*	U
1	12	0.02	12	2.1	2	5	12	0.67	12	0.07	12	1.6	12	0.04	12	210	12	0.8	12	0.05
2			12	2.1	2	6	12	0.69	12	0.07	12	1.7	12	0.04	12	210	12	0.8	12	0.05
3			12	2.1	2	8	12	0.73	12	0.07	12	1.7	12	0.05	12	220	12	0.82	12	0.05
Analysis	*	Y	*	Zn																
1	12	0.07	12	2.3																
2	12	0.07	12	2.4																
3	12	0.07	12	2.5																

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
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
Shijiazhuang Trump Scientific, Co.	Hebei, China	CNAS	17025
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
Vitkovice Testing Center	Czech Republic, Ostrava	ILAC	17025
Enviform	Stare Mesto, Trinec	ILAC	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
Luvak Inc.	Boylston, MA	PRI	17025
Chicago Spectro	Chicago, IL	A2LA	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	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

ILAC = International Laboratory Accreditation Cooperation

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: 11XC1N; AR 306; BAS 236/3, 405, 464/1, 481/1; BS CC-8, CI4, TS-15, 1A, 27, 30D, 56H, 61G, 75G, 291, 291BB, 291CC, 291DJ, 1016, 1026; CKD 223A, 234, 236, 238; CZ 2019A, 2020A, 20034 12A, 20034 14A; LECO 501-024, 501-105, 502-712, 502-919; SPL 1B, 13A, 14A; SRM 4K, 107B, 160B, 341, 342A, 361, 363, 365, 3107, 3109A, 3137, 3139A.

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 CC-8, CI4, 1A, 27, 291, 291BB, 291CC, 291DJ; CZ 20034 12A, 20034 14A.

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 291FD 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.; Hebei, China.

Form: This CRM is machined in the form of a disc, approximately 35mm in diameter and 25mm 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.

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 291FD-082720. 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.
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 17025:2017 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 35:2006 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 August 27, 2020.

Beau R. Brammer

President