Brammer Standard Company, Inc.

Certificate of Analysis

BS 50G

Certified Reference Material for Commercially Pure Iron - UNS Number K00095

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.008**	0.001	**N**	**0.0019**	0.0004
As	**0.0034**	0.0007	**Ni**	**0.0045**	0.0008
C	**0.0023**	0.0006	**O**	**0.0030**	0.0007
Co	**0.0011**	0.0004	**P**	**0.0088**	0.0006
Cr	**0.008**	0.001	**S**	**0.0033**	0.0005
Cu	**0.007**	0.001	**Sb**	**0.0005**	0.0002
Fe	**99.9**	0.1	**Si**	**0.009**	0.001
Mn	**0.010**	0.001			

Informational Values[3,4]

B (0.0001)	Ca (0.0002)	Mg (0.0002)	Mo (0.001)	Nb (0.0004)
Pb (0.00007)	Sn (0.0009)	Ti (0.003)	V (0.0003)	W (0.0007)
Zr (0.001)				

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.

Trace element information values for Cl, Ga, Ge, Ru, Se, and Zn are shown on page 3.

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

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BS 50G * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	N	*	Ni
1	12	0.0050666667	3	0.002	1	0.0015	11	0.000099	11	0.0046	12	0.0051	16	99.9	11	0.00526667	2	0.0013	3	0.003
2	4	0.006	5	0.00236667	1	0.001633333	10	0.0005	12	0.0050	5	0.005566667	16	99.9166667	12	0.00763333	2	0.00143333	5	0.00353333
3	4	0.0060666667	3	0.0024	1	0.001666667	4	0.0008667	4	0.006	5	0.006166667	14	99.92	10	0.0086	2	0.00163333	4	0.0039
4	4	0.0072	12	0.00269667	1	0.0019	3	0.001	11	0.0062	11	0.0062	16	99.92	11	0.0088	2	0.0017925	3	0.004
5	5	0.0073	15	0.00275333	3	0.002	4	0.0010333	5	0.00657	4	0.0063	16	99.92	14	0.00883333	2	0.0018	3	0.004
6	4	0.0076	5	0.0029	1	0.0021	12	0.0011667	8	0.007	11	0.0068	16	99.92	5	0.00913333	2	0.0019	12	0.00403333
7	4	0.0076	5	0.00293667	11	0.0021	5	0.0011667	4	0.00703	4	0.0068	16	99.9209	4	0.0092	2	0.00212	11	0.0041
8	3	0.008	12	0.00333333	11	0.0024	4	0.0013333	10	0.0078	4	0.006816667	16	99.93	4	0.00933333	2	0.00216667	4	0.0042
9	3	0.0082	10	0.0034	3	0.0028	5	0.0013633	4	0.0080	11	0.0069	16	99.93	4	0.0102	2	0.00226667	8	0.00425333
10	14	0.0085666667	3	0.004	1	0.002833333	11	0.0014	3	0.008	10	0.007	4	99.95	4	0.0102	2	0.00256667	4	0.00466667
11	4	0.0086333333	11	0.0042	1	0.002933333	4	0.0014333	4	0.00823	4	0.007	16	99.9533333	12	0.0106			4	0.00476667
12	4	0.0092	4	0.0046	1	0.003106667	11	0.0015333	4	0.00833	3	0.007	17	99.9656667	11	0.0106			11	0.005
13	11	0.0095666667	4	0.00476667	11	0.0033	14	0.0015333	14	0.00837	4	0.007133333			3	0.0107			4	0.00513333
14	11	0.0098	9	0.00483333			12	0.0016167	3	0.0085	14	0.007233333			3	0.011			11	0.00516667
15	11	0.0103					3	0.002	4	0.00863	8	0.00735			8	0.01126667			4	0.00526667
16	4	0.010825							3	0.009	3	0.008			4	0.0114			14	0.00533333
17									4	0.00926	12	0.008053333			4	0.0117			12	0.00545667
18									12	0.00938	4	0.0086			3	0.012				
19									11	0.0104	3	0.0091			5	0.0153				
Average		0.00814		0.003370		0.002329		0.001078		0.00781		0.00721		99.947		0.00996		0.00190		0.00455
Std Dev		0.00027		0.000085		0.000088		0.000060		0.00022		0.00019		0.015		0.00036		0.00010		0.00014
H		0.00091		0.00063		0.00055		0.00041		0.00089		0.00086		0.22		0.0010		0.00051		0.00071
U_1		0.00095		0.00064		0.00055		0.00041		0.00092		0.00088		0.22		0.0011		0.00051		0.00073
t-statistic		2.13		2.16		2.18		2.14		2.10		2.10		2.20		2.10		2.26		2.12
U_2		0.0020		0.0014		0.0012		0.00089		0.0019		0.0019		0.48		0.0022		0.0012		0.0015
U_3		0.00051		0.00037		0.00033		0.00023		0.00044		0.00043		0.14		0.00051		0.00037		0.00037
Certified		**0.008**		**0.0034**		**0.0023**		**0.0011**		**0.008**		**0.007**		**99.9**		**0.010**		**0.0019**		**0.0045**
Uncertainty		0.001		0.0007		0.0006		0.0004		0.001		0.001		0.1		0.001		0.0004		0.0008
Tolerance		0.003		0.0021		0.0018		0.0009		0.003		0.003		0.5		0.003		0.0012		0.0024

Analysis	*	O	*	P	*	S	*	Sb	*	Si
1	2	0.0013	12	0.00778	1	0.0025	12	0.0003567	3	0.005
2	2	0.0021566667	3	0.008	1	0.0028	5	0.0004	4	0.00687
3	2	0.0022333333	4	0.00803333	11	0.0028	5	0.0004	11	0.00737
4	2	0.0023	5	0.00816667	1	0.002833333	11	0.0004	14	0.00763
5	2	0.0025	7	0.00846	1	0.003	5	0.00041	11	0.0078
6	2	0.0029	11	0.00846667	12	0.003016667	12	0.00043	11	0.008
7	2	0.0029333333	4	0.00866667	11	0.0031	11	0.0005	6	0.00813
8	2	0.0032	12	0.00873333	3	0.0032	9	0.0006	10	0.0082
9	2	0.0034	11	0.0089	1	0.003266667	11	0.0007	4	0.00843
10	2	0.0034533333	14	0.0089	10	0.0033			4	0.0085
11	2	0.004	3	0.009	1	0.0033			3	0.0088
12	2	0.0054	4	0.00903333	1	0.00331			12	0.00893
13			5	0.00916667	12	0.003333333			5	0.0092
14			11	0.0093	11	0.003366667			4	0.01107
15			3	0.0094	1	0.003633333			4	0.0114
16			4	0.0094	1	0.003666667			12	0.01207
17			4	0.00946	1	0.0037			4	0.0133
18			10	0.0096	1	0.0039				
19			4	0.00976667	3	0.004				
20					1	0.004				
21					3	0.004				
Average		0.00298		0.00885		0.00327		0.00047		0.00859
Std Dev		0.00012		0.00028		0.00011		0.00011		0.00033
H		0.00060		0.00094		0.00062		0.00031		0.00093
U_1		0.00061		0.00099		0.00063		0.00032		0.00099
t-statistic		2.20		2.10		2.09		2.31		2.12
U_2		0.0014		0.0021		0.0013		0.00075		0.0021
U_3		0.00039		0.00048		0.00029		0.00025		0.00051
Certified		**0.0030**		**0.0088**		**0.0033**		**0.0005**		**0.009**
Uncertainty		0.0007		0.0006		0.0005		0.0002		0.001
Tolerance		0.0021		0.0018		0.0015		0.0005		0.003

BS 50G * Code for method Informational values listed as weight percent

Analysis	*	B	*	Ca	*	Mg	*	Mo	*	Nb	*	Pb	*	Sn	*	Ti	*	V	*	W	*	Zr
1	11	0.000006635	3	0.00013	12	0.00000467	5	0.0003333	11	0.0002	12	0.00000137	12	0.0000883	12	0.0000477	12	0.000050	12	0.0000363	12	0.000016
2	12	0.000065667	11	0.0002	5	0.000045	5	0.0005567	5	0.00021	11	0.000014	12	0.00013	5	0.00005	5	0.0000733	5	0.00005	5	0.00002
3	11	0.000097	4	0.0002	5	0.0001	12	0.00058	4	0.00033	5	0.000020	5	0.00017333	3	0.0002	5	0.0000767	5	0.0000567	11	0.0005
4	5	0.0001	11	0.0002	3	0.00012	4	0.0008333	5	0.0004	11	0.000038	5	0.0002	5	0.00022	12	0.0000873	5	0.0002533	10	0.0018
5	7	0.00033	11	0.0003	4	0.000336667	11	0.001	10	0.0007	9	0.0003	5	0.0002	5	0.00025333	5	0.0001233	3	0.0003	11	0.0018
6					4	0.0004	4	0.0010333	11	0.00085			3	0.0003	10	0.0003	5	0.0002	4	0.0008	4	0.00223
7							10	0.0011					11	0.0006	4	0.00073333	11	0.0002	4	0.0012	11	0.00223
8							11	0.0013					9	0.00066667	14	0.0009	4	0.0003	4	0.0014	4	0.002367
9							11	0.0015333					3	0.001	3	0.001	11	0.0003667	11	0.0014		
10							4	0.0016					4	0.00113333	4	0.0011	10	0.0006	11	0.0014667		
11							14	0.0018667					4	0.00116667	4	0.0012	14	0.0007				
12													10	0.0014	11	0.0024						
13													11	0.0019	17	0.034						
14													11	0.0032								
Average		0.000120		0.00021		0.000168		0.0011		0.00045		0.000075		0.0009		0.003		0.00025		0.0007		0.0014
Std Dev		0.000038		0.00013		0.000077		0.0025		0.00065		0.000012		0.0015		0.028		0.00014		0.0012		0.0045
H		0.00020		0.00024		0.00022		0.0004		0.00030		0.00017		0.0004		0.00060329		0.00025		0.0004		0.0005
U_1		0.00020		0.00027		0.00023		0.0025		0.00071		0.00017		0.0016		0.028		0.00029		0.0012		0.0045
t-statistic		2.78		2.78		2.57		2.23		2.57		2.78		2.16		2.18		2.23		2.26		2.36
U_2		0.00056		0.00075		0.00060		0.0056		0.0018		0.00049		0.0034		0.062		0.00064		0.0028		0.011
U_3		0.00025		0.00034		0.00024		0.0017		0.00075		0.00022		0.00090		0.017		0.00019		0.00088		0.0038
Informational		(0.0001)		(0.0002)		(0.0002)		(0.001)		(0.0004)		(0.00007)		(0.0009)		(0.003)		(0.0003)		(0.0007)		(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 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.

BS 50G * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Cl	*	Ga	*	Ge	*	Ru	*	Se	*	Zn
1	12	0.03	12	7.7	12	8.6	12	9.9	12	0.05	12	0.05
2	12	0.03	12	7.9	12	8.7	12	11	12	0.06	12	0.08
3	12	0.04	12	8.1	12	9.0	12	11	12	0.06		

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	PIXE
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
NSL Analytical	Cleveland, OH	ANAB	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
Luvak Inc.	Boylston, MA	PRI	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Exova	Glendale Heights, IL	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	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
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: AR 654, 657, 662, 668, 670, 875, 882, 892, 1647, 1648, 1652, 1653; BAM 043-1; BAS 111, 149/2, 149/3, 260/2, 409, 431, 464/1; BS HON T, HON U, LAS 13-2, XCCS, XCCS-1, 50A, 50B, 50C, 50D, 50E, 50F, 54F, 54H, 56E, 61G, 68E, 1016, 1018, 1026, 1035, 4820A, 8620C, 8620F; CKD 162A, 180A; DSZU CA013; ECRM 097-1D, 097-2D; IARM 27D, 27E, 28I, 28J; IMZ 110A, 112; LECO 501-280, 501-320, 501-502, 501-504, 501-644, 501-676, 501-677, 501-928, 501-993, 502-280, 502-868, 502-916, 502-918; NCS NS21006; SAR 961; SRM 10G, 11F, 55D, 132A, 160B, 166B, 361, 362, 363, 364, 365, 1165, 1166, 1167, 1263, 1264, 1264A, 1265, 1265A, 1413, 1766, 1767, 2168, 3112A.

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 — BAM 043-1; BAS 111, 409; BS HON T, HON U, 50A, 50B, 50C, 50D, 50E, 50F; DSZU CA013; ECRM 097-1D, 097-2D; LECO 501-676; NCS NS21006; SRM 1166, 1265A, 1766, 1767, 2168.

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 50G 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 Trump Scientific Co., LTD; Xingtai, China

Form: This CRM is machined in the form of a disc, approximately 38mm in diameter and 38mm 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 entire depth of the CRM may be used.

> Caution: As with any bar material, avoid spark atomic emission spectrometric burns in the center of the CRM (5 mm radius), as some segregation may be present.

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 50G-040119. 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
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 April 1, 2019.

Beau R. Brammer

President