Brammer Standard Company, Inc.

Certificate of Analysis

BS LC-7A

Certified Reference Material for Commercially Pure Iron

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.0194**	0.0008	**Mo**	**0.0034**	0.0006
As	**0.0024**	0.0003	**N**	**0.0043**	0.0005
C	**0.0025**	0.0004	**Ni**	**0.0058**	0.0005
Co	**0.0017**	0.0004	**P**	**0.013**	0.001
Cr	**0.0074**	0.0008	**S**	**0.0030**	0.0003
Cu	**0.0038**	0.0007	**Si**	**0.0056**	0.0009
Fe	**99.9**	0.1	**Ti**	**0.0004**	0.0002
Mn	**0.023**	0.001			

Informational Values[3,4]

B (0.0001)	Ca (0.0002)	Mg (0.0001)	Nb (0.0005)	O (0.005)
Pb (0.0004)	Sb (0.0006)	Sn (0.0007)	V (0.0004)	W (0.0005)
Zr (0.0006)				

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, 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 LC-7A * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N
1	3	0.0172	4	0.0018	3	0.0017	10	0.0009	12	0.0048333	11	0.00206111	16	[99.89]	14	0.02177	12	0.00223333	2	0.00398
2	11	0.0186	5	0.0021333	1	0.0019	12	0.0012	11	0.0054308	11	0.0022	16	[99.899867]	4	0.0219	11	0.0024	2	0.0041
3	4	0.01886667	3	0.0022	1	0.002	3	0.00127222	11	0.0066	12	0.0025	16	[99.9]	10	0.022	11	0.00247222	2	0.0042
4	14	0.01886667	3	0.0022111	11	0.002077778	5	0.00146667	13	0.0067333	11	0.00316667	4	99.9	11	0.02218	4	0.0028	2	0.00443333
5	3	0.019	4	0.0022667	1	0.0022	5	0.00146667	14	0.0067333	4	0.00336667	14	99.9	4	0.02257	3	0.003	2	0.00446667
6	4	0.0191	4	0.0023	1	0.0022	3	0.0015	10	0.0076	4	0.0036	16	[99.9]	3	0.023	14	0.00306667	2	0.00453333
7	5	0.01916667	5	0.0023333	1	0.002233333	4	0.00153333	4	0.0076667	5	0.00373333	16	[99.9034]	4	0.02303	4	0.00336667	2	0.00455
8	4	0.01936667	12	0.0023667	11	0.0023	14	0.0016	11	0.0077667	4	0.0038	16	[99.9042]	3	0.02307	11	0.00343333	2	0.0046
9	4	0.01976667	10	0.0024	1	0.002393333	5	0.0017	4	0.0078667	10	0.0038	16	[99.91]	4	0.02343	4	0.0037	2	0.0047
10	4	0.02006667	9	0.0026	11	0.0024	4	0.0018	3	0.0079	4	0.00385667	16	[99.91]	11	0.0239	10	0.0038	2	0.00478333
11	11	0.0201	15	0.00273	1	0.002566667	11	0.0019	3	0.008	4	0.00386667	16	[99.91]	11	0.02397	5	0.0038		
12	5	0.02033333	5	0.0027667	4	0.002766667	4	0.0022	3	0.0081667	3	0.004			3	0.024	5	0.0039		
13	3	0.02043333	5	0.0028367	1	0.002933333	4	0.0023	4	0.0082467	14	0.00406667			4	0.024	4	0.0039		
14	11	0.02061111			3	0.002988889	11	0.00246667	4	0.0083667	4	0.0045			8	0.02483	4	0.00393333		
15					3	0.003			5	0.0084	3	0.00634444			4	0.02607	3	0.004		
16					1	0.003126667			4	0.0087	3	0.0065					3	0.00517222		
Average		0.019391		0.00238		0.00251		0.001750		0.007438		0.00382		99.904		0.02323		0.00343		0.00435
Std Dev		0.000085		0.00011		0.00017		0.000078		0.000079		0.00016		0.030		0.00088		0.00015		0.00020
H		0.0014		0.00056		0.00058		0.00050		0.00090		0.00068		0.21		0.0015		0.00065		0.00072
U_1		0.0014		0.00057		0.00060		0.00051		0.00090		0.00070		0.21		0.0017		0.00067		0.00074
t-statistic		2.16		2.18		2.13		2.16		2.13		2.13		2.23		2.14		2.13		2.26
U_2		0.0030		0.0012		0.0013		0.0011		0.0019		0.0015		0.48		0.0037		0.0014		0.0017
U_3		0.00080		0.00035		0.00032		0.00029		0.00048		0.00037		0.14		0.0010		0.00036		0.00053
Certified		**0.0194**		**0.0024**		**0.0025**		**0.0017**		**0.0074**		**0.0038**		**99.9**		**0.023**		**0.0034**		**0.0043**
Uncertainty		0.0008		0.0003		0.0004		0.0004		0.0008		0.0007		0.1		0.001		0.0006		0.0005
Tolerance		0.0030		0.0012		0.0013		0.0012		0.0024		0.0021		0.5		0.004		0.0018		0.0017

Analysis	*	Ni	*	P	*	S	*	Si	*	Ti
1	12	0.00516667	12	0.0093667	1	0.0021	4	0.00396667	12	0.000061
2	11	0.00533889	4	0.0097	1	0.002333333	6	0.00456667	3	0.00012
3	4	0.00543333	4	0.0109667	1	0.002733333	4	0.00458	5	0.0001667
4	4	0.00556667	3	0.011	3	0.0028	3	0.00528889	5	0.0002567
5	11	0.00566667	10	0.012	11	0.0028	4	0.00543333	5	0.0003333
6	5	0.00586667	4	0.0123667	3	0.002822222	3	0.0056	3	0.0004
7	4	0.0059	5	0.0123667	11	0.0029	12	0.0058	5	0.0004333
8	3	0.00593889	4	0.0125	11	0.002905556	10	0.006	4	0.0005
9	14	0.00596667	3	0.0131	1	0.002933333	14	0.00636667	11	0.0005
10	4	0.00606667	3	0.0135111	10	0.003	4	0.00665	10	0.0005
11	3	0.0061	11	0.0136389	3	0.003	5	0.0074	11	0.0005333
12	4	0.00611333	11	0.0137	1	0.0031			11	0.0007167
13	11	0.0062	5	0.0138	1	0.003113333				
14			11	0.0138333	1	0.003133333				
15			14	0.0141	1	0.003333333				
16			4	0.0143667	1	0.0035				
17					1	0.003533333				
18					1	0.004				
Average		0.00584		0.01335		0.003002		0.005605		0.000377
Std Dev		0.00028		0.00053		0.000075		0.000095		0.000091
H		0.00081		0.0012		0.00062		0.00080		0.000288
U_1		0.00086		0.0013		0.00062		0.00080		0.00030
t-statistic		2.18		2.13		2.11		2.23		2.20
U_2		0.0019		0.0027		0.0013		0.0018		0.00067
U_3		0.00052		0.00068		0.00031		0.00054		0.00019
Certified		**0.0058**		**0.013**		**0.0030**		**0.0056**		**0.0004**
Uncertainty		0.0005		0.001		0.0003		0.0009		0.0002
Tolerance		0.0019		0.003		0.0013		0.0027		0.0004

BS LC-7A * Code for method Informational values listed as weight percent

Analysis	*	B	*	Ca	*	Mg	*	Nb	*	O	*	Pb	*	Sb	*	Sn	*	V	*	W	*	Zr
1	11	0.0000087	11	0.000096	12	0.00000233	5	0.0000233	2	0.0012333	12	0.000003	12	0.000346667	12	0.00015	5	0.0000467	12	0.0000327	3	0.0001
2	12	0.0000417	3	0.000143	16	0.00002	11	0.0002	2	0.0013	9	0.0000633	9	0.0004	5	0.00023	12	0.000049	5	0.0000927	5	0.0001
3	11	0.000065	3	0.00016	3	0.0000306	5	0.00026	2	0.0015667	3	0.00028462	5	0.0004	5	0.00027	5	0.0001	5	0.00020333	3	0.0003172
4	3	0.000090	11	0.0002	5	0.0001	3	0.00033333	2	0.0018	11	0.00036147	5	0.00040	5	0.0003	3	0.00010	3	0.00178333	5	0.0005333
5	3	0.0000922	4	0.0002	3	0.00019	4	0.00046667	2	0.0021	10	0.0007	5	0.000406667	5	0.00033	5	0.00011333			11	0.0006588
6	11	0.0000994	11	0.0005333	4	0.00030333	3	0.0005	2	0.00214	3	0.0007	5	0.000433333	9	0.00073	3	0.00014286			11	0.0006762
7	4	0.0002333					4	0.00053333	2	0.002525			11	0.001491667	3	0.0008	3	0.0005			10	0.0011
8	3	0.0003					11	0.00058141	2	0.0032333					3	0.00084	4	0.00103333			3	0.0015
9							5	0.0006	2	0.0034					10	0.0012	10	0.0011				
10							10	0.0007	2	0.0034533					11	0.00195						
11							11	0.0008	2	0.034												
Average		0.000116		0.00022		0.000108		0.00045		0.005		0.00035		0.00055		0.0007		0.00035		0.0005		0.0006
Std Dev		0.000028		0.00015		0.000027		0.00049		0.030		0.00039		0.00091		0.0011		0.00032		0.0011		0.0011
H		0.00020		0.00024		0.00019		0.00031		0.001		0.00028		0.00033		0.0004		0.00028		0.0003		0.0003
U_1		0.00020		0.00028		0.00020		0.00058		0.030		0.00048		0.00097		0.0012		0.00043		0.0011		0.0011
t-statistic		2.36		2.57		2.57		2.23		2.23		2.57		2.45		2.26		2.31		3.18		2.36
U_2		0.00047		0.00072		0.00050		0.0013		0.066		0.0012		0.0024		0.0027		0.0010		0.0036		0.0027
U_3		0.00017		0.00030		0.00021		0.00039		0.020		0.00051		0.00090		0.00085		0.00033		0.0018		0.00094
Informational		(0.0001)		(0.0002)		(0.0001)		(0.0005)		(0.005)		(0.0004)		(0.0006)		(0.0007)		(0.0004)		(0.0005)		(0.0006)

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 LC-7A * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Cl	*	Ga	*	Ge	*	Zn
1	12	0.03	12	7.1	12	7.7	12	0.08
2	12	0.04	12	7.1	12	7.8	12	0.09
3	12	0.07	12	7.3	12	7.8	12	0.10

Analytical Method Codes:

1 Combustion (ASTM E1019)
2 Fusion (ASTM E1019)
3 Spark Atomic Emission
4 ICP Atomic Emission
5 ICP Mass Spectrometry
6 Gravimetric
7 Photometric
8 Flame Atomic Absorption
9 GF Atomic Absorption
10 X-Ray Fluorescence
11 GD Atomic Emission
12 GD Mass Spectrometry
13 Titrimetric
14 DCP Atomic Emission
15 HG Atomic Fluorescence
16 Difference

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
LECO Corporation	St. Joseph, MI	A2LA	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Luvak Inc.	Boylston, MA	PRI	17025
Exova	Glendale Heights, IL	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	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: 13X31200A; AR 148, 654, 657, 673, 876, 882, 889, 892, 946, 961, 1647, 1648, 1650, 1652, 1653; BAM 044-1; BAS 149/3, 220/2, 342, 431, 433, 435, 459, 460, 460/1, 464/1; BS H-13, LF2B, 34D, 36D, 50B, 50D, 50F, 50G, 56H, 61G, 179C, 316D, 316E, 410C, 1009, 1018, 1020, 1026, 2205; CKD 180A, 188A; ECRM 285-2, 532-1; IMZ 110A, 114A, 130, 153A, 163A, 164, 174; KMA LCSON-001; LECO 502-257, 501-503, 501-504, 501-644, 502-414, 502-449, 502-712, 502-855, 502-894, 502-916, 502-935, 502-946, 502-946, 502-970; NCS NS 11019; SRM 16D, 55A, 55F, 153A, 160B, 361, 362, 363, 365, 1155A, 1265, 1765, 1766, 1768, 2165; SUS FE1/1.

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 044-1; BS 50D, 50F; ECRM 285-2, 532-1; KMS LCSON-001; LECO 502-257; NCS NS 11019; SRM 1265, 1766, 1768, 2165; SUS FE1/1.

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 LC-7A 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 38 mm in diameter and 38 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 down surface.

Note: Shrinkage cavities may appear in the top portion of some discs. These cavities are normal and will not affect the certified portion 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 LC-7A-100319. 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 October 3, 2019.

Beau R. Brammer

President