

Brammer Standard Company, Inc.

Certificate of Analysis

BS 1009

Certified Reference Material for 1009 Carbon Steel

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
Al	0.026	0.001		N	0.0043	0.0005
As	0.0011	0.0003		Ni	0.0129	0.0007
C	0.008	0.001		O	0.0060	0.0006
Ca	0.0033	0.0005		P	0.0118	0.0008
Co	0.0020	0.0003		S	0.0086	0.0004
Cr	0.028	0.001		Si	0.048	0.003
Cu	0.011	0.001		Sn	0.0007	0.0002
Fe	99.6	0.2		Ti	0.0007	0.0002
Mn	0.212	0.009				

Informational Values^{3,4}

B (0.0002)	Mg (0.0003)	Mo (0.003)	Nb (0.0008)	Pb (0.0004)
Sb (0.0009)	V (0.0006)	W (0.001)	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, F, Ga, Ge, Na, 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.

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	N
1	4	0.022	4	0.0010333	1	0.0056333	12	0.0014333	3	0.0017	5	0.0237	12	0.0077	17	99.559667	17	0.1993333	2	0.0028
2	4	0.02386667	5	0.0011667	3	0.006	3	0.00194	3	0.0017	17	0.025	4	0.008	11	99.57	4	0.2010333	2	0.004
3	4	0.0247	10	0.0012	1	0.0069333	3	0.00217	14	0.002	4	0.0253333	5	0.0088	16	99.6	3	0.202	2	0.0041
4	3	0.025	3	0.0013	1	0.0072	4	0.0029	4	0.0020	4	0.0271	5	0.00933333	16	99.609667	3	0.203	2	0.00427
5	4	0.02533333	3	0.0014	3	0.0072	4	0.0030333	4	0.0020333	3	0.0271	4	0.00966667	14	99.61	4	0.2035667	2	0.0043
6	14	0.02536667	5	0.0014	1	0.0079633	4	0.0030333	4	0.0020667	3	0.0271	4	0.0102	16	99.61	4	0.204	2	0.00437
7	4	0.02573333	4	0.0014	4	0.0081	4	0.0033667	12	0.0020667	4	0.0279	4	0.0102	16	99.6177	5	0.206	2	0.00443
8	4	0.02586667	11	0.0015	3	0.0082	4	0.0036233	11	0.0021	4	0.0279333	11	0.0107	16	99.62	4	0.206	2	0.00463
9	5	0.02626667	15	0.00167	1	0.0082667	3	0.0036667	5	0.0021	4	0.028	4	0.01086667	16	99.623333	4	0.2106667	2	0.00463
10	3	0.027	12	0.0017433	1	0.0084	14	0.0037667	5	0.0022733	3	0.028	3	0.011	3	99.63	14	0.2133333	2	0.00476
11	3	0.027	12	0.0018	1	0.0084333	2	0.0043667	4	0.0023	4	0.0286	3	0.011	4	99.63	10	0.214	1	0.00496
12	4	0.02706667	5	0.0018467	1	0.0086667	11	0.0049			13	0.0289667	8	0.0114			3	0.215	2	0.005
13	4	0.02725			11	0.009	4	0.005			10	0.029	14	0.01156667			11	0.218		
14	11	0.0273			3	0.009					14	0.0291333	3	0.0119			4	0.2183333		
15					1	0.009					4	0.0298	3	0.0119			4	0.2183333		
16					1	0.0091					3	0.03	10	0.012			8	0.221		
17					1	0.0095667					11	0.0319	4	0.01226667			3	0.222		
18													17	0.01233333			4	0.2237		
Average		0.02571		0.001111		0.008039		0.003323		0.001990		0.02803		0.01076		99.620		0.2116		0.00427
Std Dev		0.00084		0.000056		0.000077		0.000088		0.000087		0.00084		0.00034		0.018		0.0031		0.00015
H		0.0015		0.00041		0.00090		0.00062		0.00051		0.0016		0.0010		0.23		0.0044		0.00069
U ₁		0.0017		0.00042		0.00090		0.00063		0.00052		0.0018		0.0011		0.23		0.0054		0.00071
t-statistic		2.16		2.20		2.12		2.18		2.23		2.12		2.11		2.23		2.11		2.20
U ₂		0.0037		0.00091		0.0019		0.0014		0.0012		0.0038		0.0023		0.50		0.011		0.0016
U ₃		0.0010		0.00026		0.00046		0.00038		0.00035		0.00092		0.00053		0.15		0.0027		0.00045
Certified		0.026		0.0011		0.008		0.0033		0.0020		0.028		0.011		99.6		0.212		0.0043
Uncertainty		0.001		0.0003		0.001		0.0005		0.0003		0.001		0.001		0.2		0.009		0.0005
Tolerance		0.004		0.0009		0.003		0.0015		0.0012		0.004		0.003		0.5		0.027		0.0015

Analysis	*	Ni	*	O	*	P	*	S	*	Si	*	Sn	*	Ti						
1	12	0.01133333	2	0.0053	7	0.0104667	1	0.0074667	11	0.0401	12	0.0003733	12	0.00023						
2	4	0.01136667	2	0.0053667	3	0.011	1	0.008	3	0.041	12	0.0004533	5	0.0005						
3	8	0.0117	2	0.0055	4	0.0110333	1	0.00813	4	0.0433333	5	0.0005	3	0.0006						
4	4	0.01206667	2	0.0057033	4	0.0110667	1	0.0083	12	0.0446667	5	0.00053	3	0.0006						
5	4	0.01273333	1	0.0059567	3	0.0116	12	0.0083	4	0.0449333	5	0.0006533	5	0.00065333						
6	14	0.0128	2	0.0060667	12	0.0116667	1	0.0083333	10	0.045	3	0.0007	3	0.0007						
7	3	0.013	2	0.0061	4	0.0117667	1	0.0083667	3	0.0455	3	0.0007	4	0.0007						
8	3	0.013	2	0.0062	14	0.0119	11	0.0085	14	0.0458333	5	0.0007	4	0.0008						
9	11	0.013	2	0.0064	3	0.0119	3	0.0086	4	0.0461667	9	0.0007667	4	0.00083333						
10	4	0.0130	2	0.0064333	10	0.012	1	0.0086	6	0.0463	4	0.0008	10	0.0009						
11	4	0.01303333	2	0.0073	4	0.0120667	3	0.0086	4	0.0465	3	0.001	11	0.001						
12	3	0.0133			12	0.0120667	1	0.0088667	3	0.0473	4	0.0010667	3	0.001						
13	3	0.0133			11	0.0121	1	0.0089	4	0.05	10	0.0015	14	0.0011						
14	4	0.0141			5	0.0121333	3	0.009	3	0.051										
15	10	0.015			4	0.0125333	3	0.009	4	0.0511										
16					3	0.013	12	0.0090133	4	0.0542										
17							1	0.0092667	5	0.0592										
18							10	0.0098												
19							1	0.0098667												
20							1	0.01												
Average		0.01293		0.00602		0.011769		0.00857		0.0476		0.000746		0.000684						
Std Dev		0.00044		0.00022		0.000079		0.00025		0.0013		0.000038		0.000017						
H		0.0011		0.00079		0.0011		0.00092		0.0020		0.00036		0.00034693						
U ₁		0.0012		0.00082		0.0011		0.00096		0.0024		0.00036		0.00035						
t-statistic		2.14		2.23		2.13		2.09		2.12		2.18		2.18						
U ₂		0.0026		0.0018		0.0023		0.0020		0.0051		0.00078		0.00076						
U ₃		0.00066		0.00055		0.00057		0.00045		0.0012		0.00022		0.00021						
Certified		0.0129		0.0060		0.0118		0.0086		0.048		0.0007		0.0007						
Uncertainty		0.0007		0.0006		0.0008		0.0004		0.003		0.0002		0.0002						
Tolerance		0.0026		0.0018		0.0024		0.0020		0.009		0.0007		0.0007						

Analysis	*	B	*	Mg	*	Mo	*	Nb	*	Pb	*	Sb	*	V	*	W	*	Zr
1	12	0.0000367	3	0.00014	4	0.0011	3	0.0001	12	0.000078	12	0.0002767	12	0.0000987	12	0.000090	12	0.000015
2	4	0.0001	12	0.0001567	5	0.0013333	5	0.0001767	5	0.0001	5	0.0003	12	0.00015	5	0.0001	5	0.00002
3	3	0.00013	5	0.0002	5	0.0015667	4	0.0008	11	0.0001	5	0.0003	5	0.00018667	5	0.0001133	3	0.0004
4	7	0.00022333	3	0.00025	5	0.0016133	10	0.0008	12	0.00011	5	0.0003233	5	0.0002	12	0.00012	4	0.0006333
5	11	0.0003	12	0.0002933	12	0.0016967	11	0.0008	5	0.00013	12	0.0003267	5	0.00022667	5	0.0001833	4	0.0007
6			4	0.00042	4	0.0019333	4	0.0008667	5	0.0003	9	0.0014667	3	0.0006	11	0.0012	3	0.001
7			4	0.0005	11	0.0023	4	0.0011	3	0.0006	11	0.0018	3	0.0006	4	0.0016	10	0.0012
8			5	0.0005	10	0.0025	3	0.0018	9	0.0006	4	0.0021	4	0.0007	4	0.0020333		
9					10	0.003			3	0.0009			4	0.0007	4	0.0020667		
10					14	0.0032667			3	0.001			4	0.0007	3	0.0021		
11					3	0.004							14	0.0008	3	0.0034		
12					4	0.0047667							10	0.0008				
13					4	0.0050333							11	0.001				
14					3	0.0062							4	0.0015				
15					3	0.0073												
Average		0.000158		0.00031		0.003		0.0008		0.00039		0.0009		0.00059		0.0012		0.00057
Std Dev		0.000074		0.00026		0.013		0.0017		0.00038		0.0020		0.00073		0.0030		0.00095
H		0.00022		0.00027		0.001		0.0004		0.00029		0.0004		0.00033		0.0004		0.0003
U ₁		0.00023		0.00037		0.013		0.0018		0.00048		0.0020		0.00080		0.0030		0.0010
t-statistic		2.78		2.36		2.14		2.36		2.26		2.36		2.16		2.23		2.45
U ₂		0.00064		0.00087		0.027		0.0042		0.0011		0.0048		0.0017		0.0067		0.0025
U ₃		0.00028		0.00031		0.0070		0.0015		0.00034		0.0017		0.00046		0.0020		0.00093
Informational		(0.0002)		(0.0003)		(0.003)		(0.0008)		(0.0004)		(0.0009)		(0.0006)		(0.001)		(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. 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.

Analysis	*	Cl	*	F	*	Ga	*	Ge	*	Na	*	Ru	*	Se	*	Zn
1	12	0.04	12	0.07	12	5.4	12	7.8	12	0.01	12	18	12	0.19	12	5.0
2	12	0.06			12	5.5	12	8.0			12	19	12	0.20	12	5.1
3	12	0.07			12	5.6	12	8.0			12	19	12	0.26	12	5.3

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
Luvak Inc.	Boylston, MA	PRI	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Exova	Glendale Heights, IL	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	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, 662, 668, 670, 875, 882, 892, 961, 1647, 1648, 1652, 1653; BAS 149/2, 149/3, 260/2, 431, 464/1; BS CE 013, HON U, XCCS, XCCS-1, 50A, 50F, 54F, 54H, 56E, 61G, 68E, 250, 1016, 1018, 1026, 1035, 8620C, 8620F; CKD 162A, 180A; DSZU CA013; IARM 27D, 27E, 28I, 28J; IMZ 110A, 112; JSS 412-1; 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; SEM 10G, 11F, 55D, 55E, 132A, 160B, 166B, 293, 361, 362, 363, 364, 365, 1165, 1166, 1167, 1263, 1264, 1264A, 1265, 1265A, 1413, 1765, 1766, 1767, 2165, 2166.

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 CE 013, HON U, XCCS, 50A, 250; DSZU CA013; JSS 412-1; LECO 501-676; SRM 1265A, 1765, 1767, 2165, 2166.

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 1009 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 bar stock for this CRM was produced by Metal Men Sales, Inc.; New York, New York.

Form: This CRM is machined in the form of a disc, approximately 38mm in diameter and 19mm 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 1009-041119. 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 17025:2005 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 11, 2019.

Beau R. Brammer

President