

Brammer Standard Company, Inc.

Certificate of Analysis

BS 1016

Certified Reference Material for Carbon Steel Grade 1016 - UNS Number G10160

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
Al	0.0200	0.0006		N	0.0113	0.0008
As	0.0066	0.0004		Ni	0.107	0.004
C	0.172	0.004		P	0.011	0.001
Co	0.0193	0.0009		S	0.030	0.002
Cr	0.091	0.001		Si	0.193	0.009
Cu	0.153	0.004		Sn	0.013	0.001
Fe	98.4	0.2		Ti	0.0010	0.0003
Mn	0.77	0.01		V	0.0011	0.0002
Mo	0.040	0.002				

Informational Values^{3,4}

B (0.0003)	Ca (0.0004)	Mg (0.0007)	Nb (0.0009)	O (0.003)
Pb (0.004)	W (0.0013)	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 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 Bi, and Se 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	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N
1	4	0.0182	10	0.0057	3	0.164	4	0.016	10	0.0882	14	0.148	16	[98.3]	4	0.75	3	0.0364	2	0.0101
2	10	0.01847	9	0.00613333	4	0.1671	4	0.0181	4	0.0884	4	0.149	14	98.3	17	0.75	3	0.0365	2	0.011
3	4	0.01867	3	0.00615	1	0.16766667	10	0.0181333	4	0.0897	10	0.1497333	3	98.3209	4	0.7576667	4	0.03767	2	0.01143
4	3	0.01923	15	0.00621667	1	0.16803333	5	0.0184333	10	0.090	4	0.1500667	16	[98.325]	10	0.7586667	4	0.038	2	0.01153
5	3	0.0196	5	0.00626667	1	0.169	8	0.0185	3	0.090	4	0.1504333	16	[98.32667]	10	0.7649	17	0.03867	2	0.01163
6	10	0.0197	4	0.00628667	1	0.17	3	0.01885	4	0.09007	3	0.152	16	[98.3333]	3	0.766	7	0.03913	2	0.0117
7	3	0.0197	4	0.00633667	1	0.17	3	0.019	4	0.09007	3	0.1535	16	[98.35334]	14	0.768	4	0.0395	2	0.01173
8	3	0.0197	3	0.00645	1	0.17133333	4	0.0190333	10	0.0902	4	0.1536667	4	98.3609	3	0.77	4	0.0396	2	0.01193
9	4	0.01977	3	0.0065	1	0.1715	4	0.0191	4	0.09033	10	0.154	16	[98.365]	3	0.77	4	0.03963	2	0.01283
10	4	0.01983	4	0.0066	3	0.172	4	0.0193667	3	0.0905	4	0.1544	10	98.37	4	0.7701333	3	0.0399		
11	10	0.02	4	0.00683333	1	0.17366667	10	0.0196667	4	0.0908	10	0.155	3	98.37	4	0.7703333	4	0.03993		
12	4	0.02023	5	0.00696667	3	0.1746	10	0.0199	3	0.09155	3	0.1555	4	98.3757	3	0.7706667	10	0.040		
13	4	0.02027	3	0.007	1	0.17633333	14	0.0200	10	0.09157	8	0.156	3	98.38	4	0.7713	10	0.04033		
14	4	0.0203	5	0.00723333	3	0.177	4	0.0200667	3	0.0917	3	0.1566	17	98.38	4	0.7722667	14	0.0406		
15	3	0.021	10	0.0074	3	0.18	4	0.0201	4	0.09173	4	0.1566667	4	98.38	4	0.7735	5	0.04067		
16	3	0.0216	12	0.0075	1	0.180	3	0.0204	17	0.09233	4	0.1568667	13	98.446	10	0.777	10	0.041		
17	14	0.0218					5	0.0208	7	0.0933	3	0.157			3	0.777	4	0.0411		
18							3	0.02235	4	0.0934	3	0.16			3	0.7786	3	0.04125		
19									3	0.09345					4	0.7786667	10	0.0414		
20									5	0.09393					8	0.7813333	3	0.0418		
21									14	0.0943					4	0.785				
Average		0.01995		0.00656		0.1724		0.01930		0.0914		0.1530		98.352		0.7694		0.0395		0.01133
Std Dev		0.00061		0.00018		0.0028		0.00060		0.0017		0.0024		0.024		0.0041		0.0010		0.00048
H		0.0011		0.00068		0.0034		0.0011		0.0023		0.0031		0.43		0.0086		0.0015		0.00085
U ₁		0.0013		0.00070		0.0044		0.0012		0.0029		0.0040		0.43		0.0095		0.0018		0.00098
t-statistic		2.12		2.13		2.13		2.11		2.09		2.11		2.13		2.09		2.09		2.31
U ₂		0.0027		0.0015		0.0093		0.0026		0.0061		0.0084		0.91		0.020		0.0038		0.0023
U ₃		0.00064		0.00037		0.0023		0.00061		0.0013		0.0020		0.23		0.0040		0.00086		0.00075
Certified		0.0200		0.0066		0.172		0.0193		0.091		0.153		98.4		0.77		0.040		0.0113
Uncertainty		0.0006		0.0004		0.004		0.0009		0.001		0.004		0.2		0.01		0.002		0.0008
Tolerance		0.0027		0.0015		0.012		0.0027		0.006		0.012		0.9		0.03		0.006		0.0023

Analysis	*	Ni	*	P	*	S	*	Si	*	Sn	*	Ti	*	V
1	12	0.08833	4	0.0099	1	0.0278	4	0.1658333	4	0.0112	12	0.0003133	4	0.00048333
2	17	0.09467	4	0.0101	1	0.0282	3	0.175	9	0.01187	3	0.00045	10	0.0006
3	4	0.09863	10	0.0102	1	0.0284	5	0.1766667	10	0.0123	10	0.0008	3	0.0009
4	10	0.102	5	0.01033333	1	0.02866667	3	0.185	4	0.01237	4	0.0008233	4	0.0009
5	3	0.10233	7	0.01086667	1	0.029	10	0.1863	3	0.0124	5	0.0009	5	0.0009
6	4	0.10267	3	0.0109	3	0.0295	10	0.190	3	0.0129	10	0.001	5	0.00092333
7	4	0.109	10	0.0110	3	0.030	3	0.19	3	0.013	4	0.001	4	0.00093333
8	10	0.10903	3	0.0111	10	0.030	12	0.1900	5	0.01323	4	0.001	3	0.001
9	3	0.1092	3	0.0112	3	0.0303	14	0.1903333	4	0.01327	5	0.0010633	14	0.00103333
10	4	0.10927	4	0.01136667	12	0.03066667	6	0.191	4	0.01347	3	0.0011	4	0.00106667
11	4	0.10967	3	0.01145	3	0.0309	4	0.191	3	0.0136	4	0.0011333	4	0.0011
12	4	0.10993	3	0.012	1	0.0310	4	0.1911	3	0.01365	3	0.0012	10	0.0011
13	3	0.11	4	0.0122	3	0.03105	3	0.1976667	4	0.0138	3	0.0013	3	0.00145
14	3	0.11	12	0.01233333	1	0.03126667	4	0.198	5	0.01383	4	0.0013	3	0.00145
15	14	0.11133	3	0.0125	1	0.032	3	0.1988	4	0.01397	14	0.0013667		
16	8	0.11133	4	0.0127	4	0.0327	4	0.199	10	0.014	4	0.0014		
17	3	0.1115	10	0.013	1	0.03333333	4	0.2001			3	0.0015		
18	10	0.112	4	0.01323333			10	0.2026667						
19	4	0.1132					4	0.203						
20	3	0.115					4	0.2033333						
21	5	0.11567					17	0.203333						
22							3	0.21						
Average		0.1100		0.01115		0.03068		0.1934		0.01275		0.001000		0.001072
Std Dev		0.0022		0.00040		0.00096		0.0028		0.00045		0.000029		0.000029
H		0.0026		0.00084		0.0013		0.003593		0.00089		0.0003552		0.00036
U ₁		0.0034		0.00093		0.0016		0.0046		0.0010		0.00036		0.00036
t-statistic		2.09		2.11		2.12		2.08		2.13		2.12		2.16
U ₂		0.0071		0.0020		0.0035		0.0095		0.0021		0.00076		0.00079
U ₃		0.0016		0.00046		0.00084		0.0020		0.00053		0.00018		0.00021
Certified		0.107		0.011		0.030		0.193		0.013		0.0010		0.0011
Uncertainty		0.004		0.001		0.002		0.009		0.001		0.0003		0.0002
Tolerance		0.012		0.003		0.006		0.027		0.002		0.0009		0.0008

Analysis	*	B	*	Ca	*	Mg	*	Nb	*	O	*	Pb	*	W	*	Zr
1	5	0.00004	4	0.0000193	12	0.0000673	12	0.000061	2	0.0011	9	0.002	4	0.0000567	12	0.000018
2	5	0.0001	3	0.000135	5	0.0000767	4	0.00012	2	0.00145	12	0.0023	4	0.0001	5	0.00002
3	3	0.0002	3	0.000275	3	0.00012	5	0.0002	2	0.0015	4	0.0031	12	0.00027	3	0.0005
4	12	0.0003	3	0.000295	3	0.00017	5	0.00029	2	0.00183	5	0.0032667	5	0.00046667	3	0.00065
5	3	0.00031	4	0.0005	4	0.00037	10	0.0007	2	0.00203	3	0.0033	5	0.00065667	10	0.0007
6	3	0.00032	5	0.00126667	4	0.00053333	4	0.001	2	0.00211	5	0.0033333	4	0.00073333	4	0.0011667
7	3	0.0004			3	0.00054	4	0.0010667	2	0.0026	5	0.0036067	3	0.0012	4	0.0015
8	4	0.0005			3	0.0035	3	0.00115	2	0.00391	3	0.0043	3	0.0016	3	0.0024
9	3	0.00062					4	0.0012	2	0.00587	3	0.005	10	0.00166667	4	0.0028333
10							3	0.0013	2	0.0059	4	0.0051	3	0.0024	4	0.0047667
11							3	0.00195	2	0.00733	4	0.006	4	0.0031		
12							3	0.0021			3	0.00895	3	0.00345		
Average		0.00031		0.00042		0.0007		0.0009		0.003		0.004		0.0013		0.0015
Std Dev		0.00024		0.00055		0.0012		0.0019		0.015		0.021		0.0034		0.0045
H		0.00026		0.00028		0.0003		0.0003		0.001		0.001		0.0004		0.0004
U ₁		0.00036		0.00062		0.0013		0.0019		0.015		0.021		0.0034		0.0045
t-statistic		2.31		2.57		2.36		2.20		2.23		2.20		2.20		2.26
U ₂		0.00083		0.0016		0.0030		0.0041		0.034		0.047		0.0075		0.010
U ₃		0.00028		0.00065		0.0011		0.0012		0.010		0.013		0.0022		0.0032
Informational		(0.0003)		(0.0004)		(0.0007)		(0.0009)		(0.003)		(0.004)		(0.0013)		(0.001)

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 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.

Analysis	*	Bi	*	Se
1	3	8	3	21

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
Dirats Laboratories	Westfield, MA	ANAB	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Exova	Santa Fe Springs, CA	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
TUVRheinland	Bangalore, India	NABL	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	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: 12X357C, 13X12534, 13X12853, 13X43100, 28X6255; AR 654, 657, 670, 673, 875, 950, 1026, 1648, 1652, 1653; BAS S4, 4-88, 206/3, 245, 334, 335, 408, 409, 410/2, 433, 451, 454/1, 459, 459/2, 464/1, 485, 486; BS A11, H-13, 30D, 52D, 56H, 61C, 61G, 75G, 316D, 316E, 410C, 422, 718D, 750C, 1020, 1026, 1030, 2001, 2921, 2931, 2931A, 2931B, 2941, 8620A, 8620E; CKD 181A; ECRM 85-1, 86-1, 87-1; IARM 28D, 28E, 28F, 28G, 28H, 28I, 30G, 210B, 241A; IMZ 64/1, 112, 157; LECO 501-320, 501-501, 501-502, 501-503, 501-504, 501-505, 501-510, 501-644, 501-646, 501-675, 501-676, 501-677, 501-991, 501-993, 502-197, 502-280, 502-873, 504-646; SRM 1166, 1228, 1261A, 1264A, 1265A, 1413, 1763, 1764, 1765, 1766, 3109A, 3131A, 3162A, 3165; Y41340B.

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 — BAS 4-88, 409, 410/2, 454/1, 459/2; BS 52D, 207, 2931A; CKD 181A; LECO 501-676, 501-991, 502-873; SRM 293; Y41340B.

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 1016 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 purchased from Industrial Metals, Inc; Pultneyville, NY.

Form: This CRM is machined in the form of an approximately 60 mm hexagon disc and 19 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 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 1016-011818. 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 9001:2008 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 January 18, 2018.

Beau R. Brammer
President