

Brammer Standard Company, Inc.

Certificate of Analysis

BS 1016B

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

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values ³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.020	0.002	N	0.0065	0.0006
As	0.0030	0.0008	Nb	0.0012	0.0005
B	0.0002	0.0001	Ni	0.038	0.004
C	0.178	0.009	O	0.0020	0.0006
Ca	0.0007	0.0003	P	0.0122	0.0009
Co	0.0045	0.0009	S	0.0136	0.0009
Cr	0.112	0.006	Si	0.21	0.01
Cu	0.054	0.003	Sn	0.0041	0.0008
Fe	98.6	0.1	Ti	0.0008	0.0004
Mg	0.0002	0.0001	V	0.0033	0.0004
Mn	0.723	0.009	W	0.0008	0.0003
Mo	0.036	0.004	Zr	0.0006	0.0003
	Reference Value ¹	Estimate of Uncertainty ²	Reference Values ^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
H	<0.005		Sb	0.0014	0.0008
Pb	<0.005		Ta	<0.05	

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.

Trace element information values for Ga, Ge, Na, Re, and Zn are shown on page 4.

The requirements of ISO Guides 30, and Standards 33401 and 33405 were followed for the preparation of this Certified Reference Material and certificate of analysis.

Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895 USA
Telephone: (281) 440-9396 Fax (281) 440-4432 Website: www.brammerstandard.com

Certificate Number 1016B-020625 Page 1/7

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mg
1	3	0.018	4	0.0020333	5	0.000053	1	0.17	4	0.0005	5	0.003533	8	0.10	10	0.049	16	[98.533233]	4	0.0001
2	3	0.018433	10	0.0024	3	0.0001	1	0.17	12	0.0005633	3	0.004	4	0.103667	3	0.050233	3	98.54	5	0.000163
3	4	0.0189	4	0.0027	12	0.00013	1	0.17	4	0.0006667	10	0.0040	4	0.107	3	0.051	16	[98.55]	4	0.000167
4	5	0.019367	3	0.0027	4	0.000153	1	0.175333	4	0.0007233	5	0.004067	3	0.107333	4	0.0513	16	[98.55]	3	0.0002
5	3	0.0200	4	0.0027	11	0.0002	1	0.176	5	0.0007667	10	0.0041	3	0.11	5	0.052433	16	[98.5672]	5	0.0002
6	4	0.020	5	0.0028667	3	0.0002	1	0.176233	11	0.0008	4	0.004177	12	0.1100	3	0.052667	16	[98.57]	4	0.00022
7	3	0.020	10	0.0029	5	0.000267	1	0.176667	3	0.0008	12	0.0042	3	0.11	4	0.052833	16	[98.58]	4	0.000347
8	4	0.020067	4	0.0029	4	0.0003	1	0.1771	4	0.0008333	3	0.0045	10	0.11	3	0.053	16	[98.58]		
9	11	0.0203	4	0.0029667	5	0.000597	1	0.178			4	0.0046	4	0.111067	4	0.053133	4	98.58		
10	3	0.020333	5	0.00297			1	0.1781			4	0.004667	4	0.111567	4	0.053333	16	[98.59]		
11	3	0.0205	5	0.003			3	0.1788			11	0.0049	4	0.111967	7	0.0535	10	98.596667		
12	4	0.020633	12	0.0033			11	0.179			4	0.004933	4	0.112	4	0.053567				
13	12	0.0210	5	0.0038333			1	0.1795			4	0.004967	4	0.112667	8	0.054				
14	4	0.021167					3	0.18			8	0.005	5	0.112667	4	0.054007				
15	5	0.021533					3	0.18			4	0.005	3	0.113	3	0.0545				
16	4	0.021733					1	0.182			3	0.0050	11	0.113	10	0.054733				
17	5	0.022667					1	0.182667			3	0.005	4	0.1133	11	0.0548				
18							1	0.186667			4	0.005133	3	0.114	3	0.055				
19											3	0.005233	10	0.116	4	0.055				
20													10	0.117	4	0.0552				
21													3	0.12	10	0.056				
22													4	0.120667	4	0.0567				
23													4	0.121133	12	0.058667				
Average		0.02034		0.003025		0.00022		0.1784		0.000653		0.00453		0.1121		0.0537		98.571		0.000202
Std Dev		0.00072		0.000092		0.00016		0.0030		0.000030		0.00017		0.0050		0.0012		0.030		0.000014
H		0.0015		0.00065		0.00025		0.0043		0.00036		0.00077		0.0034		0.0023		0.19		0.00024
U ₁		0.0016		0.00066		0.00027		0.0052		0.00037		0.00079		0.0034		0.0026		0.19		0.00024
t-statistic		2.12		2.18		2.31		2.11		2.36		2.10		2.07		2.07		2.23		2.45
U ₂		0.0035		0.0014		0.00063		0.011		0.00086		0.0017		0.0070		0.0055		0.43		0.00060
U ₃		0.00085		0.00040		0.00021		0.0026		0.00031		0.00038		0.0015		0.0011		0.13		0.00023
Certified		0.020		0.0030		0.0002		0.178		0.0007		0.0045		0.112		0.054		98.6		0.0002
Uncertainty		0.002		0.0008		0.0001		0.009		0.0003		0.0009		0.006		0.003		0.1		0.0001
Tolerance		0.006		0.0024		0.0001		0.027		0.0006		0.0027		0.018		0.009		0.4		0.0001

Analysis	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	S	*	Si	*	Sn
1	8	0.70	4	0.030	2	0.0061	11	0.0003	4	0.0327667	2	0.00082	3	0.009	1	0.010667	4	0.201	12	0.003567
2	4	0.708	4	0.0303	2	0.0061	4	0.000733	10	0.0344333	2	0.001377	4	0.009667	1	0.012733	10	0.205	4	0.003567
3	10	0.716	12	0.0323333	2	0.006227	3	0.000833	3	0.0349667	2	0.001667	10	0.0110	1	0.0129	4	0.20536667	4	0.0036
4	3	0.718667	3	0.034	2	0.006367	12	0.00085	4	0.0360333	2	0.001833	3	0.011333	3	0.0129	4	0.206	4	0.0037
5	4	0.719333	4	0.0351667	2	0.0064	5	0.001043	4	0.0366667	2	0.0020	5	0.011667	1	0.012977	6	0.21	5	0.003767
6	3	0.72	11	0.0359	2	0.006467	5	0.001133	5	0.0366667	2	0.0023	3	0.0118	10	0.013	3	0.21	5	0.003987
7	10	0.72	4	0.0359	2	0.0065	3	0.0012	4	0.0367	2	0.002633	10	0.012	4	0.013033	3	0.21	4	0.004
8	3	0.721	3	0.0362333	2	0.006513	5	0.0013	4	0.0381333	2	0.0036	3	0.012	1	0.013133	11	0.211	3	0.004
9	4	0.721	3	0.0366667	2	0.006733	4	0.0021	3	0.039			3	0.012	11	0.0134	7	0.21266667	3	0.0040
10	11	0.722	4	0.0367333	2	0.0069	4	0.0027	3	0.039			4	0.012033	1	0.0135	3	0.214	5	0.004133
11	10	0.722	3	0.037	2	0.007			3	0.0393			4	0.012033	1	0.0135	10	0.21433333	4	0.0045
12	4	0.723	3	0.037					12	0.0396667			4	0.0121	1	0.0137	5	0.21433333	10	0.0046
13	4	0.7249	4	0.0370333					8	0.040			4	0.0121	3	0.0139	3	0.21633333	3	0.0048
14	4	0.726333	4	0.0371667					10	0.04			4	0.0123	1	0.014	4	0.218	3	0.005
15	3	0.726667	4	0.0372667					3	0.04			11	0.0124	3	0.014	3	0.219		
16	3	0.728	5	0.0379					4	0.0400667			4	0.0128	1	0.014133	4	0.2199		
17	4	0.728033	8	0.038					4	0.0402			3	0.013	1	0.0142	3	0.22		
18	4	0.7289	3	0.038					3	0.0403333			4	0.0137	1	0.0149	4	0.22046667		
19	7	0.729	10	0.038					11	0.041			13	0.014	12	0.015667	4	0.22466667		
20	4	0.7292	10	0.0381					4	0.0416667			5	0.014167			4	0.225		
21	3	0.73	10	0.039					4	0.041833			12	0.015333			4	0.2263		
22	4	0.743															4	0.233		
Average		0.7230		0.03594		0.00653		0.00122		0.0385		0.00203		0.0122		0.01356		0.2146		0.00409
Std Dev		0.0085		0.00099		0.00022		0.00070		0.0025		0.00084		0.0014		0.00044		0.0033		0.00047
H		0.0090		0.0019		0.00090		0.00046		0.0020		0.00056		0.0012		0.0012		0.0047		0.00074
U ₁		0.0090		0.0022		0.00093		0.00047		0.0020		0.00057		0.0012		0.0013		0.0057		0.00075
t-statistic		2.08		2.09		2.23		2.26		2.09		2.36		2.09		2.10		2.08		2.16
U ₂		0.019		0.0045		0.0021		0.0011		0.0042		0.0013		0.0025		0.0028		0.012		0.0016
U ₃		0.0040		0.0010		0.00062		0.00034		0.00091		0.00048		0.0005		0.00063		0.0025		0.00043
Certified		0.723		0.036		0.0065		0.0012		0.038		0.0020		0.0122		0.0136		0.21		0.0041
Uncertainty		0.009		0.004		0.0006		0.0005		0.004		0.0006		0.0009		0.0009		0.01		0.0008
Tolerance		0.027		0.012		0.0018		0.0011		0.012		0.0018		0.0027		0.0027		0.03		0.0024

BS 1016B * Code for method Certified values listed as weight percent

Analysis	*	Ti	*	V	*	W	*	Zr
1	5	0.00026	4	0.0025667	12	0.000467	5	0.000047
2	12	0.0003	12	0.0029667	5	0.000507	12	0.000081
3	5	0.000333	10	0.003	5	0.000537	11	0.0006
4	5	0.000417	3	0.003	5	0.000567	4	0.000733
5	4	0.0005	3	0.0032	4	0.0006	4	0.000767
6	3	0.0006	4	0.0032	3	0.0008	10	0.000833
7	3	0.0008	5	0.0032667	4	0.000867	3	0.0009
8	3	0.001	4	0.0033	11	0.0015		
9	4	0.0011	3	0.0033	4	0.0015		
10	4	0.001167	4	0.0033333				
11	4	0.0012	5	0.0036				
12	11	0.0015	4	0.00363				
13			11	0.0037				
14			4	0.0039				
Average		0.00076		0.00326		0.00082		0.00057
Std Dev		0.00042		0.00012		0.00041		0.00036
H		0.00039		0.00067		0.00040		0.00040
U ₁		0.00040		0.00069		0.00041		0.00041
t-statistic		2.20		2.16		2.31		2.45
U ₂		0.00087		0.0015		0.00094		0.0010
U ₃		0.00025		0.00040		0.00031		0.00038
Certified		0.0008		0.0033		0.0008		0.0006
Uncertainty		0.0004		0.0004		0.0003		0.0003
Tolerance		0.0007		0.0012		0.0007		0.0005

BS 1016B * Code for method Reference values listed as weight percent

Analysis	*	H	*	Pb	*	Sb	*	Ta
1	2	0.000061	12	0.000016	5	0.000633	5	0.00023
2	2	0.000065	5	0.00002	5	0.000657	4	0.001033
3	2	0.00017	5	0.000032	12	0.000787	4	0.008633
4	2	0.0002	5	0.00004	5	0.000923	3	0.0087
5	2	0.000207	3	0.0002	5	0.0017		
6	2	0.000267	3	0.0002	4	0.002633		
7	2	0.000467	4	0.0003333	3	0.0027		
Average		0.000091		0.0000211		0.00143		0.00112
Std Dev		0.000014		0.0000018		0.00092		0.00037
H		0.00019		0.00012		0.00049		0.00044
U ₁		0.00019		0.00012		0.00050		0.00058
t-statistic		2.45		2.45		2.45		3.18
U ₂		0.00046		0.00030		0.0012		0.0018
U ₃		0.00017		0.00011		0.00046		0.00092
Reference		<0.005		<0.005		0.0014		<0.05
Uncertainty						0.0008		
Tolerance						0.0013		

For each element, in accordance with the requirements of ISO 17034 and 33405, 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 Standard 33405:2024 section 10.

BS 1016B * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ga	*	Ge	*	Na	*	Re	*	Zn											
1	12	5.2	12	15	12	0.01	12	0.03	12	2.0											
2	12	5.2	12	15			12	0.04	12	2.1											
3	12	5.3	12	15			12	0.04	12	2.2											

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 | | |
| 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
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Raghavendra Spectro Metallurgical Laboratory	Karnataka, India	NABL	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Vitkovice Testing Center	Hulvaky, Ostrava	Czech Accreditation Institute	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Institut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
APL, Inc	Milwaukee, WI	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	A2LA	17025
APL, Inc	Milwaukee, WI	A2LA	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

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: 12X10180C, 12X11572, 12X15254, 12X15266U, 12X353G, 12X354B, 12X357B, 12XLA2D; AR 546, 644, 645, 659, 660, 662, 867, 871, 872, 883, 895, 951, 1652, 1653; BAS 206/3, 218/2, 236/3, 405, 464/1; BS CCS-2, CSN-1, HON T, XCCS, XCCS-2, 12B, 30D, 43A, 45B, 46B, 56H, 61G, 171B, 300A, 1016, 1018, 1018A, 1020, 1026, 1026A, 1030A, 1040, 1931, 2023, 2921, 2931, 2931A, 2931B, 2941, 3012, 3942, 3992, 4130, 4142SE, 4330MOD, 4340, 8620F; CKD 170, 171, 227, 244C, 249C; CZ CM22A, 306A; DSZU CA031; ECRM 85-1, 86-1, 87-1; IARM 28F, 28G, 28I, 28J, 31C, 199C; IMZ 63, 68, 112, 132; JSM M402-4; LECO 501-503, 501-677, 502-060, 502-280, 502-449, 502-856, 502-863, 802-893, 502-903, 502-913, 502-970, 503-537; SRM 72G, 160B, 361, 362, 363, 1138A, 1262, 1263A.

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 CCS-2, 1018, 2931A, 2931B, 2941, 3012, 3992; SRM 1138A.

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 1016B 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 Republic Steel; Blasdeil, NY.

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 Standard 33403 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 1016B-020625. 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 17034:2016 as a Reference Material Producer for the production of Certified Reference Materials and Reference Materials (our current Certificate Number 656.02 expires 01/31/2027)

Brammer Standard Company's Chemical Laboratory is accredited by A2LA to ISO Standard 17025:2017. (Our current Certificate Number 656.01 expires 01/31/2027)

By current Certificate Number 10539 expiring 01/01/2027, the Quality System of Brammer Standard Company, Inc., is registered to ISO 9001:2015 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 Standard 33401:2024 Reference materials - Contents of certificates, labels and accompanying documentation

ISO Standard 33403:2024 Reference materials – Requirements and recommendations for use

ISO Standard 17034:2016 General requirements for the competence of reference material producers

ISO Standard 33405:2024 Reference Materials – Approaches for characterization and assessment of homogeneity and stability

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 February 05, 2025.

Beau R. Brammer

President