

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 1026

Certified Reference Material for Carbon Steel Grade 1026 - UNS Number G10260

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
Al	0.0330	0.0009		Sb	0.0019	0.0003
As	0.0100	0.0006		Si	0.268	0.005
C	0.260	0.004		Sn	0.0112	0.0005
Ca	0.0017	0.0003		V	0.0016	0.0004
Co	0.0072	0.0004		W	0.0021	0.0004
Cr	0.163	0.003				
Cu	0.247	0.004				
Fe	[97.8]	0.5				
Mn	0.715	0.008				
Mo	0.0289	0.0007				
N	0.0083	0.0006				
Ni	0.096	0.002				
O	0.0031	0.0005				
P	0.0171	0.0007				
S	0.0191	0.0006				

Informational Values^{3,4}

B (0.0002)	Mg (0.0002)	Nb (0.0004)	Pb (0.0002)	Ta (0.002)
Ti (0.0004)	Zr (0.0002)			

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.

⁴ Values in parentheses are not certified and are provided for information only.

Trace element information values for Cd, Ce, Cl, Ga, Ge, K, La, Na, Re, and Zn are shown on page 4.

The requirements of ISO Guides 31, 34, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis. This is a Certified Reference Material as defined by ISO Guide 30.

BS 1026

* Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe
1	5	0.030333	9	0.00905	1	0.254667	4	0.001467	5	0.005767	5	0.154	5	0.237333	13	97.71433
2	4	0.030667	3	0.0096	1	0.255667	4	0.001533	5	0.0062	4	0.156	4	0.2391	16	98.05867
3	3	0.0316	5	0.0098	1	0.25825	3	0.00163	12	0.0065	4	0.157667	10	0.241	16	98.06667
4	10	0.0316	5	0.009933	1	0.259667	8	0.001867	4	0.006733	4	0.16	3	0.242333	4	98.06833
5	4	0.031733	4	0.010133	1	0.2599	14	0.002033	4	0.006733	3	0.162	4	0.246267	4	98.09333
6	3	0.033	5	0.010633	1	0.2606	4	0.002044	4	0.0069	10	0.163	4	0.246667	16	98.1
7	12	0.0332	4	0.010989	1	0.260667	4	0.002133	5	0.007133	4	0.163885	3	0.247	10	98.12
8	3	0.0332	12	0.0115	1	0.262	4	0.00234	3	0.0072	4	0.165	14	0.248333	16	98.12667
9	5	0.033333	5	0.011533	3	0.262	4	0.0073	14	0.166667	4	0.248407	8	0.248667	3	98.17667
10	4	0.033386	4	0.0118	1	0.265	8	0.00751	5	0.167333	8	0.248667	4	0.249		
11	14	0.0338			1	0.265933	14	0.007567	10	0.168	4	0.249				
12	4	0.0339			3	0.268	4	0.0076	3	0.17	10	0.249667				
13	4	0.033933			1	0.268			4	0.1705	3	0.25				
14	10	0.036067									4	0.252333				
Average		0.03299		0.00995		0.2599		0.001691		0.00715		0.1631		0.2467		97.84
Std dev		0.00098		0.00050		0.0047		0.000080		0.00024		0.0035		0.0056		0.40
H		0.0012		0.00066		0.0038		0.00034		0.00058		0.0029		0.0037		0.52
U ₁		0.0015		0.00083		0.0060		0.00035		0.00062		0.0045		0.0067		0.65
t-statistic		2.16		2.26		2.18		2.36		2.20		2.18		2.16		2.31
U ₂		0.0033		0.0019		0.013		0.00082		0.0014		0.010		0.015		1.51
U ₃		0.00088		0.00059		0.0037		0.00029		0.00040		0.0027		0.0039		0.50
Certified		0.0330		0.0100		0.260		0.0017		0.0072		0.163		0.247		[97.8]
Uncertainty		0.0009		0.0006		0.004		0.0003		0.0004		0.003		0.004		0.5
Tolerance		0.0033		0.0019		0.013		0.0008		0.0014		0.010		0.015		1.5

Analysis	*	Mn	*	Mo	*	N	*	Ni	*	O	*	P	*	S	*	Sb
1	3	0.705	4	0.026333	2	0.0081	3	0.0849	2	0.002367	4	0.015167	12	0.0180	5	0.001367
2	10	0.706333	3	0.026367	2	0.008167	5	0.084933	2	0.0025	7	0.0156	1	0.018025	4	0.001667
3	4	0.710667	4	0.027333	2	0.0082	12	0.0875	2	0.002933	10	0.0161	1	0.0183	4	0.001742
4	14	0.710667	12	0.0275	2	0.008333	10	0.090433	2	0.003133	5	0.016133	1	0.0189	5	0.0018
5	4	0.712333	5	0.027533	2	0.0084	5	0.093367	2	0.003425	4	0.0170	3	0.0190	5	0.0020
6	3	0.714	4	0.028167	2	0.008733	4	0.093733	2	0.003567	14	0.0171	10	0.0190	5	0.0022
7	5	0.715333	7	0.0284	2	0.008767	4	0.093833	4	0.0172	1	0.019	5	0.002233		
8	8	0.717	10	0.028467	2	0.00884	3	0.095	4	0.0174	3	0.0192	12	0.0024		
9	4	0.717333	4	0.028517			8	0.095233	12	0.0175	1	0.0199				
10	4	0.718767	4	0.0287			14	0.096333	3	0.0178	1	0.020233				
11	4	0.722333	4	0.028733			4	0.096633	4	0.017889	1	0.0203				
12	4	0.725361	14	0.029			3	0.0971	10	0.0179	1	0.020667				
13	3	0.73	3	0.029			4	0.097433	3	0.0180	1	0.0210				
14	10	0.731	10	0.029			4	0.100767	13	0.018467						
15			3	0.030												
16			5	0.0300												
Average		0.715		0.02886		0.00831		0.0958		0.00314		0.01709		0.01907		0.00191
Std dev		0.012		0.00088		0.00025		0.0021		0.00027		0.00090		0.00047		0.00015
H		0.008		0.0011		0.00061		0.0021		0.00042		0.0008		0.0009		0.00035
U ₁		0.014		0.0014		0.00066		0.0029		0.00050		0.0012		0.0010		0.00038
t-statistic		2.16		2.13		2.36		2.16		2.57		2.16		2.18		2.36
U ₂		0.031		0.0030		0.0016		0.0063		0.0013		0.0027		0.0022		0.00090
U ₃		0.0083		0.00075		0.00055		0.0017		0.00052		0.00071		0.00061		0.00032
Certified		0.715		0.0289		0.0083		0.096		0.0031		0.0171		0.0191		0.0019
Uncertainty		0.008		0.0007		0.0006		0.002		0.0005		0.0007		0.0006		0.0003
Tolerance		0.031		0.0030		0.0016		0.006		0.0013		0.0027		0.0022		0.0009

BS 1026 * Code for method Certified values listed as weight percent

Analysis	*	Si	*	Sn	*	V	*	W
1	4	0.263667	5	0.0100	5	0.001233	5	0.001967
2	14	0.264667	5	0.0108	4	0.00153	12	0.0020
3	3	0.266	14	0.011	4	0.001667	5	0.0021
4	4	0.266333	4	0.011133	5	0.0018	4	0.0021
5	4	0.269	9	0.011267	12	0.0019	5	0.0022
6	3	0.269333	4	0.011358	3	0.002	4	0.00232
7	3	0.27	3	0.0114	5	0.002033	5	0.0024
8	5	0.272667	10	0.0114	14	0.0021		
9	10	0.275	5	0.0116	10	0.0023		
10	4	0.275658	5	0.0116				
11	4	0.276	5	0.011633				
12	4	0.278467	3	0.012				
13			4	0.012267				
Average		0.2681		0.01123		0.00155		0.00211
Std dev		0.0069		0.00056		0.00014		0.00019
H		0.0039		0.00070		0.00033		0.00036
U ₁		0.0079		0.00089		0.00036		0.00041
t-statistic		2.20		2.18		2.31		2.45
U ₂		0.017		0.0019		0.00083		0.0010
U ₃		0.0050		0.00054		0.00028		0.00038
Certified		0.268		0.0112		0.0016		0.0021
Uncertainty		0.005		0.0005		0.0004		0.0004
Tolerance		0.017		0.0019		0.0008		0.0010

BS 1026 * Code for method Informational values listed as weight percent

Analysis	*	B	*	Mg	*	Nb	*	Pb	*	Ta	*	Ti	*	Zr
1	4	0.0000367	5	0.00012	5	0.0001	5	0.000163	5	0.001533	5	0.0002	5	0.0000163
2	5	0.00013	14	0.00015	5	0.000147	5	0.000167	3	0.0047	5	0.00035	12	0.00010
3	4	0.0002	8	0.000183	5	0.000203	12	0.00017	14	0.0049	12	0.00044	3	0.0005
4	12	0.00020	3	0.00019	4	0.000267	5	0.00017			5	0.000533	4	0.0008
5	14	0.000533	5	0.0002	5	0.0003	5	0.0002			4	0.0009	4	0.0009
6			5	0.000367	12	0.00030	5	0.0003			3	0.002	14	0.000967
7			12	0.00038	3	0.0011	14	0.000667			14	0.002033	4	0.0019
8			4	0.000393	4	0.0012	3	0.0017			4	0.002467		
9			4	0.000478	4	0.001367	9	0.001733			4	0.003197		
10					14	0.0016	4	0.0027						
11					4	0.0025								
Average		0.000171		0.000244		0.000358		0.000246		0.00205		0.000431		0.000169
Std dev		0.000020		0.000021		0.000038		0.000033		0.00038		0.000056		0.000049
H		0.00019		0.00020		0.00022		0.00020		0.00036		0.00023		0.00019
U ₁		0.00019		0.00021		0.00022		0.00021		0.00052		0.00024		0.00020
t-statistic		2.78		2.31		2.23		2.26		4.30		2.31		2.45
U ₂		0.00053		0.00047		0.00050		0.00047		0.0022		0.00055		0.00048
U ₃		0.00024		0.00016		0.00015		0.00015		0.0013		0.00018		0.00018
(Informational)		(0.0002)		(0.0002)		(0.0004)		(0.0002)		(0.002)		(0.0004)		(0.0002)

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 times 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 Tolerance is the half width of the 95 % confidence interval for measurements 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.

For further information regarding the confidence interval for the certified value see ISO Guide 35:2006 section 6.

BS 1026

* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	* Cd	* Ce	* Cl	* Ga	* Ge	* K	* La	* Na	* Re	* Zn											
1	4	2	4	4	12	0.26	12	6.0	5	16	12	0.50	4	4	12	0.21	5	0.30	12	5.6	
2					5	8.4	5	16										5	0.31	5	7.6
3					5	8.4	5	17										5	0.32	5	8.0
4					5	8.4	12	26												5	8.0
5																				4	11

Analytical Method Codes:

1	Combustion (ASTM E1019)	7	Photometric	13	Titrimetric
2	Fusion (ASTM E 1019)	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

Laboratory

Brammer Standard Company, Inc.
Dirats Laboratories
NSL Analytical
Laboratory Testing, Inc.
Exova
Brammer Standard Company, Inc.
Northern Analytical Laboratory, Inc.
National Analysis Center For Iron And Steel
Shiva Analyticals
Luvak Inc.

Location

Houston, TX
Westfield, MA
Cleveland, OH
Hatfield, PA
Glendale Heights, IL
Houston, TX
Londonderry, NH
Beijing, China
Hoskote, Bangalore
Boylston, MA

Registrar

A2LA
ACCLASS
ACCLASS
PRI/Nadcap
A2LA
A2LA
PRI/Nadcap
CNAS
NABL
PRI/Nadcap

Accreditation

17025, Guide 34
17025
17025
17025
17025
17025, Guide 34
17025
17025
17025
17025
17025

A2LA = American Association for Laboratory Accreditation
ACCLASS = ANSI-ASQ National Accreditation Board
CNAS = China National Accreditation Service
NABL = National Accreditation Board for Testing and Calibration Laboratories
Nadcap = National Aerospace and Defense Contractors Accreditation Program
PRI = Performance Review Institute

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Certificate Number 1026-041114 Page 4/6

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 E 1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025. Methods of analysis used were a those listed on page 4.

Traceability: The following Certified Reference Materials were used to validate the analytical data listed on pages 2-4 — AR 646, 657, 660, 676, 875, 878, 1651, 1653, 1656; BAS 087/1, 410/2, 434/2, 435, 456, 460, 460/2, 464/1; BS CCS-1, CSN 2-1, CSN 4, 30D, 56H, 61G, 63A, 63B, 1030, 2931, 2942, 4932; ECRM 037/1, 85/1, 86/1, 87/1, 327/2, 284/1, 285/1, 287/1; IARM 209B, 242A; IMZ 1.8/3, 112, 119, 159; JK 47; HMS HOCS-001; SRM 10G, 13F, 30F, 55D, 72F, 73B, 133A, 139B, 160B, 293, 361, 362, 363, 1246, 1263A, 1763, 1766, 3108, 3109A, 3110, 3127A, 3137, 3163, 3165, 3168A, 3169; 501-102, 501-320, 501-501, 501-503, 501-504, 501-506, 501-644, 501-676, 501-677, 501-993, 502-102, 502-194, 502-416; 12x349, 12x356, 12x357, 12x10180.

Homogeneity: This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the following Reference Materials — BAS 460/2; BS CCS-1, CSN 2-1, CSN 4, 63A, 63B, 2931, 2942, 4932; ECRM 284/1, 285/1; KM HOCS-001; SRM 139B, 361, 293; 502-416.

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 1026 is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Source: The bar stock for this CRM was produced by Hamilton Specialty Bar, Hamilton, Ontario.

Form: This CRM is machined in the form of a disc, approximately 38 mm in diameter and 19 mm thick by Brammer Standard Company, Inc.

Use: This CRM is intended for use in spark atomic emission 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 you use for production specimens. Avoid overheating the sample during surface preparation.

Certificate Number: The unique identification number for this certificate of analysis is 1026-041114. You may obtain information on revisions of certificates from the internet at www.brammerstandard.com.

Safety Notice: A Material Safety Data Sheet (MSDS) 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. Phone: (281) 440-9396 Web: www.brammerstandard.com
14603 Benfer Road
Houston, Texas 77069-2895 USA Fax: (281) 440-4432 Email: contact@brammerstandard.com

Brammer Standard Company, Inc., is accredited by the American Association For Laboratory Accreditation (A2LA) to ISO Guide 34 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

- E 826 Standard Practice for Testing Homogeneity of a Metal Lot or Batch in Solid Form by Spark Atomic Emission Spectrometry
- E 1019 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
- E 1806 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 9001:2008 Quality Management Systems - Requirements
- ISO Guide 30:1992 Terms and definitions used in connection with reference materials + 2008 amendment
- ISO Guide 31:2000 Reference materials - Contents of certificates and labels
- ISO Guide 33:2000 Uses of certified reference materials
- ISO Guide 34:2009 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, 1916 Race Street, Philadelphia, PA, 19103.

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, 2014.

Beau R. Brammer