

# Brammer Standard Company, Inc.

## Certificate of Analysis

### BS 1045

Certified Reference Material for Carbon Steel Grade 1045 - UNS Number G10450

	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	<b>Certified Values<sup>3</sup></b>	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>
<b>As</b>	<b>0.0050</b>	0.0005		<b>Nb</b>	0.001
<b>C</b>	<b>0.458</b>	0.004		<b>Ni</b>	0.002
<b>Ca</b>	<b>0.0013</b>	0.0003		<b>O</b>	0.0005
<b>Co</b>	<b>0.0056</b>	0.0006		<b>P</b>	0.0006
<b>Cr</b>	<b>0.108</b>	0.003		<b>S</b>	0.001
<b>Cu</b>	<b>0.190</b>	0.004		<b>Sb</b>	0.0005
<b>Fe</b>	<b>98.1</b>	0.1		<b>Si</b>	0.004
<b>Mn</b>	<b>0.796</b>	0.009		<b>Sn</b>	0.0007
<b>Mo</b>	<b>0.0170</b>	0.0007		<b>Ti</b>	0.0003
<b>N</b>	<b>0.0113</b>	0.0008			

### Informational Values<sup>3,4</sup>

Al (0.001)	B (0.0003)	Mg (0.0002)	Pb (0.0005)	V (0.002)
W (0.0007)	Zr (0.0009)			

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.

<sup>2</sup> 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.

<sup>3</sup> Values are given in weight percent. Values in brackets are reported by difference.

<sup>4</sup> Values in parentheses are not certified and are provided for information only.

Trace element information values for Ag, Cl, Ga, Ge, In, Na, Re, Ru, 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	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N
1	3	0.004	3	0.450	11	0.0008	10	0.00396667	10	0.10	3	0.185	3	98.04	8	0.7773333	4	0.0159667	2	0.01
2	5	0.0045333	1	0.45	4	0.0010	3	0.0040	4	0.105	4	0.1853333	16	[98.05]	4	0.7826667	3	0.0162	2	0.01057
3	10	0.0046	1	0.4543333	4	0.00105667	12	0.0049	3	0.105	3	0.186	4	98.0633333	4	0.787	14	0.0162333	2	0.0110
4	12	0.0046	1	0.4543333	4	0.00113333	4	0.0050	4	0.1066667	5	0.1863333	10	98.07	4	0.7893333	4	0.0162667	2	0.0112
5	4	0.0049333	1	0.45466667	4	0.00117667	5	0.0054	4	0.1067	4	0.1873333	16	[98.0733]	14	0.79	3	0.0164	2	0.0112
6	5	0.0049667	1	0.455	14	0.00133333	5	0.0056	4	0.1073333	4	0.189	16	[98.0761667]	4	0.7907	4	0.0167667	2	0.0112
7	11	0.0051	1	0.45536667	4	0.00136667	5	0.00574333	4	0.1079	4	0.1896	16	[98.08]	4	0.791	10	0.0168333	2	0.01127
8	15	0.0051433	1	0.457	3	0.00138	3	0.0059	10	0.1086667	10	0.19	14	98.1	4	0.7914	4	0.0168667	2	0.01137
9	5	0.0051567	11	0.458	5	0.002	14	0.00593333	14	0.1086667	11	0.19	16	[98.1]	10	0.7926667	4	0.0172	2	0.0115
10	4	0.0051667	3	0.46			3	0.006	3	0.11	4	0.1905	16	[98.1398667]	3	0.795	5	0.0172667	2	0.0115
11	3	0.0052	1	0.462			4	0.006	5	0.111	10	0.1906667	13	98.2736667	4	0.7986667	11	0.0174	2	0.01203
12	5	0.0053333	1	0.47			10	0.0061	4	0.111	14	0.1926667			3	0.80	3	0.018		
13	14	0.0059333	1	0.4713333			4	0.00616667	11	0.113	4	0.1942333			11	0.802	10	0.018		
14							11	0.0065	13	0.1142667	4	0.1973333			4	0.8043333	4	0.0182667		
15							4	0.00653333			3	0.201			10	0.81				
16															3	0.829				
Average		0.004974		0.457849		0.001254		0.005583		0.108229		0.190333		98.078		0.795694		0.016976		0.01132
Std Dev		0.000088		0.000088		0.000071		0.000082		0.000085		0.000082		0.033		0.000079		0.000085		0.00044
H		0.00075		0.0067		0.00043		0.00078		0.0031		0.0042		0.21		0.0092		0.0013		0.0011
U <sub>1</sub>		0.00075		0.0067		0.00044		0.00079		0.0031		0.0042		0.21		0.0092		0.0013		0.0011
t-statistic		2.18		2.18		2.31		2.14		2.16		2.14		2.23		2.13		2.16		2.23
U <sub>2</sub>		0.0016		0.015		0.0010		0.0017		0.0067		0.0089		0.48		0.020		0.0028		0.0026
U <sub>3</sub>		0.00045		0.0041		0.00034		0.00044		0.0018		0.014		0.0049		0.00074		0.00077		
Certified		<b>0.0050</b>		<b>0.458</b>		<b>0.0013</b>		<b>0.0056</b>		<b>0.108</b>		<b>0.190</b>		<b>98.1</b>		<b>0.796</b>		<b>0.0170</b>		<b>0.0113</b>
Uncertainty		0.0005		0.004		0.0003		0.0006		0.003		0.004		0.1		0.009		0.0007		0.0008
Tolerance		0.0016		0.015		0.0010		0.0018		0.009		0.012		0.5		0.027		0.0028		0.0026

Analysis	*	Nb	*	Ni	*	O	*	P	*	S	*	Sb	*	Si	*	Sn	*	Ti		
1	10	0.023	4	0.05506667	2	0.00316667	5	0.0058	1	0.0206	5	0.00146667	10	0.21	9	0.0078667	10	0.0007		
2	4	0.0235333	5	0.0563333	2	0.00356667	4	0.00614	1	0.0212	11	0.0016	4	0.21053333	4	0.0083	5	0.00073		
3	4	0.0244667	4	0.0579	2	0.00357	5	0.0063	1	0.0218	12	0.00163333	6	0.2113	4	0.0083333	5	0.0008		
4	4	0.0248333	4	0.0583	2	0.0037	3	0.00643333	1	0.0218	5	0.00166667	4	0.21133333	5	0.0084	5	0.00092		
5	4	0.0249333	14	0.05966667	2	0.00396667	4	0.00663333	1	0.0218	5	0.00175	14	0.21233333	3	0.0085	4	0.0009667		
6	14	0.0249333	11	0.0599	2	0.00431667	3	0.0068	1	0.0223	14	0.0018	4	0.21333333	4	0.0086333	4	0.0010		
7	11	0.0255	3	0.06	2	0.0045	14	0.0069	3	0.0230	4	0.02139	4	0.2139	4	0.0087	4	0.0010		
8	3	0.0257	4	0.06013333	2	0.005	10	0.007	10	0.0230	4	0.21433333	5	0.0087667	11	0.0012				
9	3	0.026	4	0.0607	2	0.00526667	3	0.007	11	0.0233	11	0.215	4	0.0089	3	0.0012				
10	10	0.0265	3	0.061			4	0.00746667	1	0.0233	3	0.216	10	0.009	3	0.0014				
11	4	0.0266333	10	0.061			4	0.00753333	1	0.0236	5	0.219	3	0.009						
12	5	0.0269333	4	0.06113333			4	0.00756667	1	0.0238	3	0.22								
13	4	0.0286333					11	0.008	1	0.0239	10	0.22333333								
14									3	0.0250	3	0.22466667								
15									1	0.0250										
Average		0.0257		0.0595		0.00401		0.006890		0.02311		0.00173		0.215362		0.00840		0.001060		
Std Dev		0.0011		0.0018		0.00020		0.000088		0.00090		0.00013		0.000085		0.00039		0.000060		
H		0.0015		0.0023		0.00068		0.00086		0.0015		0.00049		0.0045		0.0009		0.0004081		
U <sub>1</sub>		0.0019		0.0029		0.00071		0.00086		0.0017		0.00051		0.0045		0.0010		0.00041		
t-statistic		2.18		2.20		2.31		2.18		2.14		2.57		2.16		2.23		2.26		
U <sub>2</sub>		0.0041		0.0064		0.0016		0.0019		0.0037		0.0013		0.010		0.0023		0.00093		
U <sub>3</sub>		0.0011		0.0019		0.00055		0.00052		0.0010		0.00053		0.0026		0.00068		0.00030		
Certified		<b>0.026</b>		<b>0.060</b>		<b>0.0040</b>		<b>0.0069</b>		<b>0.023</b>		<b>0.0017</b>		<b>0.215</b>		<b>0.0084</b>		<b>0.0011</b>		
Uncertainty		0.001		0.002		0.0005		0.0006		0.001		0.0005		0.004		0.0007		0.0003		
Tolerance		0.004		0.006		0.0016		0.0019		0.004		0.0013		0.012		0.0023		0.0009		

**BS 1045**

\* Code for method

Informational values listed as weight percent

Analysis	*	Al	*	B	*	Mg	*	Pb	*	V	*	W	*	Zr
1	3	0.0002	7	0.00014333	12	0.000080	12	0.00021667	12	0.00054	12	0.00034667	5	0.00002967
2	12	0.0003033	12	0.00015	3	0.00018	5	0.00027333	5	0.0009	5	0.0006	3	0.0002
3	11	0.0006	4	0.0002	5	0.0002	3	0.0003	5	0.0009967	5	0.00063	4	0.0007
4	5	0.0007667	4	0.0003	4	0.0003	5	0.0003	4	0.0010333	5	0.00065	10	0.0012
5	5	0.0008933	3	0.00036	4	0.00044667	5	0.0003	5	0.0011333	4	0.00073333	3	0.0015
6	3	0.002	3	0.0004			5	0.00035	3	0.0012	3	0.0013	11	0.0018
7	4	0.0021					9	0.00036667	4	0.0014				
8							11	0.001	10	0.0016				
9							10	0.0011	4	0.0018333				
10							3	0.0012	14	0.0018667				
11									11	0.0024				
12									3	0.0027				
13									4	0.0033333				
Average		0.0010		0.00026		0.00024		0.00054		0.0016		0.0007		0.0009
Std Dev		0.0027		0.00020		0.00019		0.00073		0.0047		0.0016		0.0025
H		0.0004		0.00025		0.00025		0.00032		0.0005		0.0004		0.0004
U <sub>1</sub>		0.0027		0.00032		0.00031		0.00079		0.0047		0.0016		0.0025
t-statistic		2.45		2.57		2.78		2.26		2.18		2.57		2.57
U <sub>2</sub>		0.0066		0.00083		0.00086		0.0018		0.010		0.0042		0.0065
U <sub>3</sub>		0.0025		0.00034		0.00039		0.00057		0.0028		0.0017		0.0027
Informational		(0.001)		(0.0003)		(0.0002)		(0.0005)		(0.002)		(0.0007)		(0.0009)

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<sub>L</sub>), calculated from its standard deviation (S<sub>L</sub>) and its uncertainty estimate (U<sub>L</sub>), is used as the weight (W<sub>L</sub>) for its mean (M<sub>L</sub>). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U<sub>1</sub> is the combined uncertainty from homogeneity and labs. U<sub>2</sub> is U<sub>1</sub> multiplied by the coverage factor (95 % t-statistic). U<sub>3</sub> is U<sub>2</sub> 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 U<sub>3</sub> 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 1045**

\* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ag	*	Cl	*	Ga	*	Ge	*	In	*	Na	*	Re	*	Ru	*	Zn
1	12	1	12	0.03	12	6.1	12	14	12	0.21	12	0.02	12	0.01	12	0.06	12	35
2	12	1	12	0.03	12	6.2	12	14	12	0.24	12	0.02	12	0.01	12	0.06	12	35
3	12	1	12	0.04	12	6.3	12	14	12	0.25	12	0.03	12	0.01			12	35

**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
LECO Corporation	St. Joseph, MI	A2LA	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Exova	Glendale Heights, IL	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Luvak Inc.	Boylston, MA	PRI	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 646, 654, 657, 662, 675, 882, 892, 961, 1647, 1648, 1650, 1652, 1653; BAS 149/3, 220/2, 342, 431, 433, 435, 459, 460, 460/1, 463, 464/1, 466/1; BS CA316-2, CSN-4, H-13, LF2B, 34D, 36D, 50G, 56H, 61G, 84H, 179C, 180B, 316D, 316E, 410C, 1009, 1020, 2205, 9632P; CKD 180A, 188A, CZ 2003A; ECRM 284-2D; IARM 5E, 212D; IMZ 110A, 114A, 130, 153A, 163A, 164, 174; JK 37; LECO 501-320, 501-501, 501-644, 501-676, 501-993, 501-414, 502-449, 502-712, 502-855, 502-870, 502-894, 502-913, 502-916, 502-918, 502-928, 502-935, 502-945, 502-971; NCS NS 11022, NS 21006; SRM 160B, 361, 362, 363, 1155, 1155A, 1265, 1765, 1766, 3109A, 3131A.

**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 CSN 2-2, HON U, 56B, 56C, 56G, 202, 2972; LECO 501-676; NCS NS 21006; SRM 293, 1228.

**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 1045 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 Alton Steel, Inc.; Alton, IL.

**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, 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 1045-092719. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://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](http://www.brammerstandard.com)

Fax: (281) 440-4432 Email: [contact@brammerstandard.com](mailto: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](http://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](http://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 September 27, 2019.

Beau R. Brammer

President