

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS 56H

Certified Reference Material for AISI 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>Al</b>	<b>0.0009</b>	0.0002		<b>P</b>	<b>0.0096</b>	0.0004
<b>As</b>	<b>0.0056</b>	0.0004		<b>Pb</b>	<b>0.0004</b>	0.0001
<b>B</b>	<b>0.0002</b>	0.0001		<b>S</b>	<b>0.0234</b>	0.0005
<b>C</b>	<b>0.457</b>	0.003		<b>Sb</b>	<b>0.0025</b>	0.0002
<b>Ca</b>	<b>0.0012</b>	0.0002		<b>Si</b>	<b>0.210</b>	0.003
<b>Co</b>	<b>0.0078</b>	0.0003		<b>Sn</b>	<b>0.0124</b>	0.0004
<b>Cr</b>	<b>0.098</b>	0.001		<b>Ta</b>	<b>0.0011</b>	0.0002
<b>Cu</b>	<b>0.299</b>	0.003		<b>Ti</b>	<b>0.0009</b>	0.0002
<b>Mg</b>	<b>0.0002</b>	0.0001		<b>V</b>	<b>0.0295</b>	0.0007
<b>Mn</b>	<b>0.772</b>	0.006		<b>W</b>	<b>0.0007</b>	0.0002
<b>Mo</b>	<b>0.0419</b>	0.0008		<b>Zr</b>	<b>0.0007</b>	0.0003
<b>N</b>	<b>0.0106</b>	0.0005				
<b>Nb</b>	<b>0.0009</b>	0.0001				
<b>Ni</b>	<b>0.154</b>	0.002				
<b>O</b>	<b>0.0025</b>	0.0004				

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

Fe [97.8]\*

\* By difference

<sup>1</sup> 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.

<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 4 for more information on its calculation.

<sup>3</sup> Values are given in weight percent.

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

Trace element information value for Ga 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.

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu
1	4	0.00058	3	0.0046	5	0.00012	3	0.440	4	0.0010	5	0.0064	5	0.089	4	0.290
2	3	0.00060	10	0.0047	4	0.00015	1	0.451	4	0.0010	5	0.0068	5	0.096	3	0.291
3	5	0.00073	5	0.0048	3	0.00017	1	0.456	4	0.0010	5	0.0071	4	0.096	5	0.291
4	5	0.00081	5	0.0049	4	0.00020	1	0.456	3	0.0011	5	0.0074	5	0.097	10	0.292
5	5	0.00090	9	0.0050	5	0.00020	1	0.456	3	0.0011	3	0.0074	10	0.098	3	0.295
6	5	0.00097	4	0.0059	14	0.00022	1	0.458	4	0.0011	4	0.0075	5	0.098	4	0.296
7	5	0.00107	5	0.0063	3	0.00026	1	0.459	14	0.0012	4	0.0075	3	0.099	4	0.296
8	14	0.00110	14	0.0065	3	0.00027	3	0.459	4	0.0013	10	0.0076	4	0.099	14	0.297
9			5	0.0069			1	0.461	3	0.0014	3	0.0078	4	0.099	3	0.300
10			5	0.0069			1	0.462	5	0.0015	3	0.0080	3	0.100	4	0.301
11			0	0.0069			3	0.462	4	0.0017	8	0.0083	4	0.101	5	0.301
12			0	0.0069			1	0.462			14	0.0088	14	0.101	4	0.306
13							1	0.463			8	0.0089	3	0.103	8	0.309
14							1	0.466			4	0.0090	4	0.107	5	0.312
15							1	0.470								
Average		0.000851		0.00562		0.000207		0.4572		0.00119		0.00779		0.0983		0.2990
Std dev		0.000092		0.00030		0.000045		0.0033		0.00012		0.00033		0.0015		0.0033
H		0.00019		0.00039		0.00013		0.0048		0.00021		0.00045		0.0018		0.0036
U <sub>1</sub>		0.00021		0.00049		0.00013		0.0058		0.00024		0.00056		0.0023		0.0049
t-statistic		2.36		2.26		2.36		2.14		2.23		2.16		2.16		2.16
U <sub>2</sub>		0.00050		0.0011		0.00031		0.013		0.00054		0.0012		0.0050		0.010
U <sub>3</sub>		0.00018		0.00035		0.00011		0.0032		0.00016		0.00032		0.0013		0.0028
<b>Certified</b>		<b>0.0009</b>		<b>0.0056</b>		<b>0.0002</b>		<b>0.457</b>		<b>0.0012</b>		<b>0.0078</b>		<b>0.098</b>		<b>0.299</b>
<b>Uncertainty</b>		<b>0.0002</b>		<b>0.0004</b>		<b>0.0001</b>		<b>0.003</b>		<b>0.0002</b>		<b>0.0003</b>		<b>0.001</b>		<b>0.003</b>
Tolerance		0.0005		0.0011		0.0002		0.013		0.0005		0.0012		0.005		0.010

Analysis	*	Mg	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P
1	3	0.00008	3	0.760	5	0.0396	2	0.0087	5	0.00030	5	0.144	2	0.0016	4	0.0080
2	5	0.00010	4	0.762	4	0.0408	2	0.0092	5	0.00030	5	0.149	2	0.0017	5	0.0082
3	5	0.00010	4	0.762	5	0.0408	3	0.0107	5	0.00047	4	0.149	2	0.0020	5	0.0083
4	4	0.00020	4	0.762	4	0.0408	2	0.0108	5	0.00089	5	0.149	2	0.0028	5	0.0086
5	4	0.00020	14	0.766	3	0.0410	2	0.0109	4	0.00100	5	0.150	2	0.0035	3	0.0090
6	5	0.00020	5	0.767	4	0.0412	2	0.0110	10	0.00120	3	0.154	2	0.0039	5	0.0097
7	8	0.00020	5	0.768	5	0.0412	2	0.0111	5	0.00160	4	0.154			3	0.0100
8	5	0.00020	3	0.768	3	0.0416	2	0.0111	5	0.00160	4	0.154			3	0.0101
9	4	0.00020	10	0.771	10	0.0420	2	0.0113	3	0.00200	4	0.155			14	0.0103
10	5	0.00023	4	0.783	4	0.0428			3	0.00200	10	0.156			10	0.0104
11	14	0.00030	3	0.784	3	0.0432			14	0.00240	8	0.157			4	0.0104
12			4	0.793	4	0.0437					14	0.157			5	0.0110
13			4	0.797	14	0.0440					3	0.157			4	0.0114
14					5	0.0459					4	0.157			4	0.0114
15											3	0.160				
Average		0.000189		0.7718		0.04193		0.01061		0.000917		0.1540		0.00252		0.00960
Std dev		0.000039		0.0060		0.00087		0.00046		0.000081		0.0021		0.00025		0.00039
H		0.00012		0.0070		0.0011		0.00052		0.00019		0.0023		0.00028		0.00050
U <sub>1</sub>		0.00013		0.0092		0.0014		0.00070		0.00021		0.0031		0.00038		0.00063
t-statistic		2.23		2.18		2.16		2.31		2.23		2.14		2.57		2.16
U <sub>2</sub>		0.00029		0.020		0.0030		0.0016		0.00047		0.0067		0.0010		0.0014
U <sub>3</sub>		0.000086		0.0056		0.00080		0.00054		0.00014		0.0017		0.00040		0.00036
<b>Certified</b>		<b>0.0002</b>		<b>0.772</b>		<b>0.0419</b>		<b>0.0106</b>		<b>0.0009</b>		<b>0.154</b>		<b>0.0025</b>		<b>0.0096</b>
<b>Uncertainty</b>		<b>0.0001</b>		<b>0.006</b>		<b>0.0008</b>		<b>0.0005</b>		<b>0.0001</b>		<b>0.002</b>		<b>0.0004</b>		<b>0.0004</b>
Tolerance		0.0002		0.020		0.0030		0.0016		0.0005		0.007		0.0010		0.0014

Analysis	*	Pb	*	S	*	Sb	*	Si	*	Sn	*	Ta	*	Ti	*	V
1	9	0.00020	1	0.0190	3	0.0018	5	0.200	3	0.0110	5	0.000005	5	0.0005	3	0.0260
2	3	0.00030	3	0.0190	14	0.0022	6	0.204	5	0.0114	5	0.00005	5	0.0005	4	0.0280
3	14	0.00030	5	0.0204	5	0.0022	4	0.208	3	0.0118	5	0.0002	5	0.0010	5	0.0283
4	5	0.00037	1	0.0210	10	0.0024	4	0.208	3	0.0118	14	0.0013	5	0.0010	5	0.0290
5	5	0.00040	3	0.0216	5	0.0024	4	0.209	5	0.0118	5	0.0019	5	0.0010	5	0.0297
6	5	0.00040	1	0.0222	5	0.0024	3	0.209	5	0.0118	5	0.0019	4	0.0011	3	0.0299
7	5	0.00041	1	0.0226	5	0.0025	14	0.213	5	0.0124	5	0.0025	3	0.0012	5	0.0300
8	5	0.00043	1	0.0231	5	0.0026	10	0.214	10	0.0125	5	0.0025	5	0.0012	4	0.0301
9	5	0.00044	1	0.0233	5	0.0028	5	0.216	5	0.0126					5	0.0301
10	5	0.00047	1	0.0240	5	0.0030	3	0.216	3	0.0129					4	0.0301
11	5	0.00050	3	0.0244	9	0.0030			5	0.0131					10	0.0302
12			1	0.0246					14	0.0140					3	0.0302
13			10	0.0261					9	0.0142					14	0.0306
14			1	0.0268											4	0.0320
15			1	0.0268												
Average		0.000395		0.02341		0.00250		0.2099		0.01237		0.00113		0.00088		0.02951
Std dev		0.000054		0.00057		0.00017		0.0031		0.00041		0.00014		0.00013		0.00071
H		0.00015		0.00078		0.00028		0.0028		0.00056		0.00021		0.00019		0.0009
U <sub>1</sub>		0.00016		0.00097		0.00033		0.0042		0.00070		0.00025		0.00023		0.0011
t-statistic		2.23		2.14		2.23		2.26		2.18		2.36		2.36		2.16
U <sub>2</sub>		0.00035		0.0021		0.00073		0.010		0.0015		0.00059		0.00055		0.0024
U <sub>3</sub>		0.00011		0.00054		0.00022		0.0030		0.00042		0.00021		0.00019		0.00065
<b>Certified</b>		<b>0.0004</b>		<b>0.0234</b>		<b>0.0025</b>		<b>0.210</b>		<b>0.0124</b>		<b>0.0011</b>		<b>0.0009</b>		<b>0.0295</b>
<b>Uncertainty</b>		<b>0.0001</b>		<b>0.0005</b>		<b>0.0002</b>		<b>0.003</b>		<b>0.0004</b>		<b>0.0002</b>		<b>0.0002</b>		<b>0.0007</b>
<b>Tolerance</b>		<b>0.0004</b>		<b>0.0021</b>		<b>0.0007</b>		<b>0.010</b>		<b>0.0015</b>		<b>0.0006</b>		<b>0.0005</b>		<b>0.0024</b>

Analysis	*	W	*	Zr
1	5	0.00053	5	0.0005
2	5	0.00068	5	0.0005
3	5	0.00070	5	0.0007
4	5	0.00070	3	0.0010
5	5	0.00075	14	0.0011
6	5	0.00080		
7	5	0.00080		
8	14	0.00100		
Average		0.000710		0.00074
Std dev		0.000084		0.00014
H		0.00018		0.00018
U <sub>1</sub>		0.00020		0.00023
t-statistic		2.36		2.78
U <sub>2</sub>		0.00046		0.00064
U <sub>3</sub>		0.00016		0.00029
<b>Certified</b>		<b>0.0007</b>		<b>0.0007</b>
<b>Uncertainty</b>		<b>0.0002</b>		<b>0.0003</b>
<b>Tolerance</b>		<b>0.0005</b>		<b>0.0006</b>

Analysis	*	Fe
1	14	97.4
2	5	97.8
3	4	97.8
4	3	97.9
5	4	97.9
6	5	97.9
Average		97.78
Std dev		0.25
H		0.49
U <sub>1</sub>		0.55
t-statistic		2.57
U <sub>2</sub>		1.40
U <sub>3</sub>		0.57
<b>(Certified)</b>		<b>(97.8)</b>

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<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> times 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 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.

Analysis	*	Ga
1	5	8.8

**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     |                           |
| 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

<u>Laboratory</u>	<u>Location</u>	<u>Registrar</u>	<u>Accreditation</u>
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Gerdau Ameristeel	St. Paul, MN	ABS	9001
Dirats Laboratories	Westfield, MA	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
LECO Corporation	St. Joseph, MI	BSI	9001
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
NSL Analytical	Cleveland, OH	PRI/Nadcap	17025
VHG Labs	Manchester, NH	A2LA	17025, Guide 34

A2LA = American Association for Laboratory Accreditation

ABS = ABS Quality Evaluations

BSI = British Standards Institution

CNAS = China National Accreditation Service

Nadcap = National Aerospace and Defense Contractors Accreditation Program

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 of 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 those listed on page 4.

**Traceability:** The following Certified Reference Materials were used to validate the analytical data listed on pages 2-4 — SRM: 293, 361, 362, 1224, 1227, 1261, 1263a, 1264, 1269, 1763, 1766, 1767, 2942, 3101a, 3102a, 3107, 3109a, 3112a, 3113, 3114, 3121, 3126a, 3128, 3131a, 3132, 3134, 3136, 3137, 3139a, 3150, 3155, 3161a, 3162a, 3163, 3165, 3169; 501-024, 501-501, 501-506, 501-644, 501-646, 501-664, 501-676, 501-677, 502-195, 502-348, 502-449, 502-809; IARM: 28B, 28C, 200A, 200B; AR: 644, 659, 660, 669, 878, 1653; BAS: 149/2, 460/1; ECRM 084-1; IMZ: 73, 1.73, 1.8/3, 1.81, 1.84, 112, 130, 135, 139; BS: 15A, 2931A, CSN 2-1, CSN 2-2, CSN-2D.

**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 — SRM: 1224, 1227, 1767; BS: CSN-2D, 15A, 2941, 2942.

**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 56H 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 Gerdau Ameristeel, St. Paul, MN.

**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 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 56H-061912. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://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.**  
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 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](http://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](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 June 19, 2012.

Beau R. Brammer