

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS 93F

Certified Reference Material for Stainless Steel Grade 440C - UNS Number S44004

	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	Certified Values <sup>3</sup>	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>
<b>Al</b>	<b>0.0052</b>	0.0006	<b>Sb</b>	<b>0.0016</b>	0.0005
<b>As</b>	<b>0.0056</b>	0.0005	<b>Si</b>	<b>0.49</b>	0.01
<b>C</b>	<b>1.047</b>	0.007	<b>Sn</b>	<b>0.0059</b>	0.0009
<b>Ca</b>	<b>0.0019</b>	0.0004	<b>Ti</b>	<b>0.0012</b>	0.0003
<b>Co</b>	<b>0.021</b>	0.002	<b>V</b>	<b>0.057</b>	0.002
<b>Cr</b>	<b>16.72</b>	0.06	<b>W</b>	<b>0.0016</b>	0.0005
<b>Cu</b>	<b>0.132</b>	0.004			
<b>Fe</b>	<b>[80.2]</b>	0.4			
<b>Mn</b>	<b>0.59</b>	0.01			
<b>Mo</b>	<b>0.46</b>	0.01			
<b>N</b>	<b>0.051</b>	0.001			
<b>Nb</b>	<b>0.0029</b>	0.0005			
<b>Ni</b>	<b>0.187</b>	0.005			
<b>O</b>	<b>0.0031</b>	0.0004			
<b>P</b>	<b>0.0266</b>	0.0009			

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

B (0.0001)

Mg (0.0006)

Pb (0.0002)

S (<0.0025)

Zr (0.001)

<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. 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 Bi, Cl, Ga, Ge, Hf, K, 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 93F** \* Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe
1	5	0.0040	5	0.003933	1	1.026	3	0.00158	10	0.016	4	15.96667	12	0.1170	10	79.90
2	5	0.004633	3	0.004	1	1.03	4	0.00175	12	0.0185	14	16.47	10	0.123333	16	[80.16]
3	4	0.004803	4	0.005133	3	1.04	4	0.001833	4	0.018867	4	16.55	3	0.124	4	80.16667
4	4	0.005167	5	0.005533	1	1.046667	4	0.0020	8	0.019833	4	16.60	4	0.124333	16	[80.16667]
5	14	0.0057	9	0.0059	1	1.047667	12	0.0021	4	0.020233	3	16.60	4	0.128667	16	[80.20]
6	4	0.0058	15	0.00592	1	1.050867	5	0.002133	5	0.021633	4	16.71447	4	0.129033	16	[80.21907]
7	3	0.0065	5	0.006133	1	1.0510	4	0.002467	14	0.022333	4	16.71933	3	0.13	16	[80.24]
8	4	0.006567	12	0.0065	1	1.052667			4	0.022867	3	16.73	14	0.130667	13	80.24767
9	3	0.007	5	0.007033	1	1.056333			4	0.023333	4	16.739	5	0.130833	14	80.65
10					1	1.057667			5	0.024567	10	16.78237	10	0.131		
11					3	1.06			5	0.025033	13	16.78367	4	0.1345		
12					1	1.063333					10	16.90667	10	0.135133		
13					1	1.066667					4	17.0	8	0.135667		
14											10	17.15	4	0.138667		
15													5	0.141733		
16													4	0.143333		
Average		0.00518		0.00560		1.0467		0.00193		0.0213		16.7191		0.1318		80.211
Std dev		0.00026		0.00027		0.0058		0.00019		0.0010		0.0037		0.0027		0.062
H		0.00053		0.00055		0.010		0.00038		0.0010		0.100		0.0026		0.45
U <sub>1</sub>		0.00059		0.00061		0.012		0.00042		0.0014		0.10		0.0038		0.46
t-statistic		2.31		2.31		2.18		2.45		2.23		2.16		2.13		2.31
U <sub>2</sub>		0.0014		0.0014		0.025		0.0010		0.0031		0.22		0.0080		1.06
U <sub>3</sub>		0.00046		0.00047		0.0071		0.00039		0.0009		0.058		0.0020		0.35
<b>Certified</b>		<b>0.0052</b>		<b>0.0056</b>		<b>1.047</b>		<b>0.0019</b>		<b>0.021</b>		<b>16.72</b>		<b>0.132</b>		<b>[80.2]</b>
<b>Uncertainty</b>		<b>0.0006</b>		<b>0.0005</b>		<b>0.007</b>		<b>0.0004</b>		<b>0.002</b>		<b>0.06</b>		<b>0.004</b>		<b>0.4</b>
Tolerance		0.0014		0.0014		0.025		0.0010		0.003		0.22		0.008		1.1

Analysis	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	Sb
1	14	0.555333	4	0.428433	2	0.048557	5	0.001533	4	0.146667	2	0.002533	4	0.023033	5	0.0011
2	4	0.573	7	0.437	2	0.0488	5	0.001733	12	0.1700	2	0.002933	7	0.023267	5	0.0013
3	4	0.585667	4	0.44	2	0.049986	5	0.00181	8	0.177333	2	0.00300	12	0.0240	5	0.0017
4	3	0.586	4	0.4562	2	0.051053	5	0.002333	4	0.1796	2	0.003143	5	0.024333	5	0.001833
5	12	0.59	3	0.461	2	0.0513	4	0.0026	3	0.18	2	0.003167	10	0.0255	12	0.0021
6	4	0.5900	10	0.461667	2	0.05148	3	0.0028	4	0.180333	2	0.003325	10	0.0257		
7	10	0.590733	4	0.461667	2	0.051667	4	0.003033	3	0.182	2	0.003333	3	0.026		
8	4	0.596333	3	0.47	2	0.051667	4	0.003267	4	0.184167	2	0.0042	5	0.0260		
9	7	0.599667	4	0.470667	2	0.051767	10	0.0034	4	0.184667	2	0.004677	3	0.0261		
10	3	0.60	10	0.478	2	0.051833	12	0.0035	4	0.185333			4	0.026167		
11	10	0.605	4	0.486667	2	0.051967	14	0.0039	5	0.188267			4	0.027067		
12	4	0.606567	4	0.490667					10	0.190			4	0.027367		
13	4	0.606667	10	0.51					10	0.190067			14	0.029233		
14	4	0.614067							14	0.191667			4	0.030		
15	4	0.653333							4	0.196667						
16									10	0.196667						
17									5	0.201633						
Average		0.5854		0.4614		0.0510		0.00289		0.1874		0.00313		0.0266		0.00163
Std dev		0.0055		0.0060		0.0016		0.00013		0.0033		0.00017		0.0010		0.00016
H		0.0067		0.0057		0.0015		0.00043		0.0032		0.00044		0.0011		0.00036
U <sub>1</sub>		0.0087		0.0083		0.0022		0.00045		0.0045		0.00047		0.0015		0.00039
t-statistic		2.14		2.18		2.23		2.23		2.12		2.31		2.16		2.78
U <sub>2</sub>		0.019		0.018		0.0049		0.0010		0.010		0.0011		0.0032		0.0011
U <sub>3</sub>		0.0050		0.0050		0.0015		0.00030		0.0023		0.00036		0.00087		0.00049
<b>Certified</b>		<b>0.59</b>		<b>0.46</b>		<b>0.051</b>		<b>0.0029</b>		<b>0.187</b>		<b>0.0031</b>		<b>0.0266</b>		<b>0.0016</b>
<b>Uncertainty</b>		<b>0.01</b>		<b>0.01</b>		<b>0.001</b>		<b>0.0005</b>		<b>0.005</b>		<b>0.0004</b>		<b>0.0009</b>		<b>0.0005</b>
Tolerance		0.02		0.02		0.005		0.0010		0.010		0.0011		0.0032		0.0011

**BS 93F** \* Code for method Certified values listed as weight percent

Analysis	*	Si	*	Sn	*	Ti	*	V	*	W
1	10	0.44	9	0.0039	5	0.000933	12	0.0490	3	0.0009
2	4	0.44533	5	0.004667	12	0.0010	4	0.051733	5	0.001267
3	10	0.455867	12	0.0049	5	0.001067	4	0.0553	5	0.001767
4	12	0.4620	5	0.0058	5	0.001167	7	0.055467	5	0.0020
5	10	0.475	5	0.0059903	4	0.0013	4	0.0569	4	0.002033
6	6	0.480333	5	0.0066	5	0.001323	3	0.058	5	0.0023
7	4	0.480367	4	0.0068	4	0.001643	5	0.058067		
8	3	0.486	5	0.007167	3	0.0017	3	0.0591		
9	4	0.488333	4	0.008467	4	0.0022	4	0.059333		
10	4	0.491667	3	0.0085			10	0.060333		
11	4	0.4943					4	0.061167		
12	5	0.498967					5	0.064167		
13	4	0.499333								
14	3	0.50								
15	14	0.502333								
16	4	0.523333								
17	4	0.546667								
Average		0.4872		0.00590		0.00115		0.0568		0.00163
Std dev		0.0052		0.00026		0.00010		0.0019		0.00027
H		0.0059		0.00056		0.00032		0.0016		0.00036
U <sub>1</sub>		0.0079		0.00062		0.00034		0.0024		0.00045
t-statistic		2.12		2.26		2.31		2.20		2.57
U <sub>2</sub>		0.017		0.0014		0.00078		0.0054		0.0011
U <sub>3</sub>		0.0040		0.00044		0.00026		0.0016		0.00047
<b>Certified</b>		<b>0.49</b>		<b>0.0059</b>		<b>0.0012</b>		<b>0.057</b>		<b>0.0016</b>
<b>Uncertainty</b>		<b>0.01</b>		<b>0.0009</b>		<b>0.0003</b>		<b>0.002</b>		<b>0.0005</b>
<b>Tolerance</b>		0.02		0.0014		0.0008		0.005		0.0011

**BS 93F** \* Code for method Informational values listed as weight percent

Analysis	*	B	*	Mg	*	Pb	*	S	*	Zr
1	5	0.000021	5	0.00031	12	0.0000023	2	0.0002	5	0.00036
2	12	0.00010	12	0.00050	5	0.000013	1	0.000267	12	0.00070
3	3	0.00011	5	0.000867	3	0.0006	1	0.00028	14	0.0018
4	4	0.000133					1	0.0005	4	0.001933
5	5	0.0003					12	0.00053	3	0.0022
6							1	0.0006		
7							1	0.000643		
8							1	0.001167		
9							1	0.001167		
10							1	0.001213		
11							3	0.0015		
12							3	0.002		
13							10	0.0022		
Average		0.000133		0.0006		0.00021		0.0009		0.0014
Std dev		0.000047		0.0015		0.00017		0.0019		0.0063
H		0.00021		0.0003		0.00022		0.0003		0.0003
U <sub>1</sub>		0.00021		0.0015		0.00028		0.0019		0.0063
t-statistic		2.78		4.30		4.30		2.18		2.78
U <sub>2</sub>		0.00059		0.0064		0.0012		0.0042		0.018
U <sub>3</sub>		0.00026		0.0037		0.00069		0.0012		0.0079
<b>(Informational)</b>		<b>(0.0001)</b>		<b>(0.0006)</b>		<b>(0.0002)</b>		<b>(&lt;0.0025)</b>		<b>(0.001)</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> 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 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 93F

\* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis *	Bi	* Cl	* Ga	* Ge	* Hf	* K	* Na	* Re	* Zn
1	12 0.012	12 0.15	12 15	5 6	12 1.0	12 0.30	12 0.17	12 0.24	12 0.58
2			5 26	12 21		5 11		5 0.24	
3				5 22				5 0.28	
4				5 22				5 0.30	
5				5 23					

### 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

### Laboratory

Brammer Standard Company, Inc.  
LECO Corporation  
Laboratory Testing, Inc.  
NSL Analytical  
Luvak Inc.  
Elemental Analysis, Inc.  
National Analysis Center For Iron And Steel  
Evans Analytical Group  
Instytut Metalurgii Zelaza  
Northern Analytical Laboratory, Inc.  
Exova

### Location

Houston, TX  
St. Joseph, MI  
Hatfield, PA  
Cleveland, OH  
Boylston, MA  
Lexington, KY  
Beijing, China  
Liverpool, NY  
Gliwice, Poland  
Londonderry, NH  
Glendale Heights, IL

### Registrar

A2LA  
A2LA  
PRI/Nadcap  
ACLASS  
PRI/Nadcap  
A2LA  
CNAS  
A2LA  
PCA  
PRI/Nadcap  
A2LA

### Accreditation

17025, Guide 34  
17025  
17025  
17025  
17025  
17025  
17025  
17025  
17025  
AB 554  
17025  
17025

A2LA = American Association for Laboratory Accreditation

ACCLASS = ANSI-ASQ National Accreditation Board  
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 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: 12X353, 12X356, 12X52986, 13X14212, 13X31254, 13X41001, 13X43100; 501-024, 501-320, 501-501, 501-503, 501-504, 501-505, 501-644, 501-646, 501-664, 501-675, 501-677, 501-678, 501-991, 501-993, 502-257, 502-348, 502-414, 502-416, 502-869; AR 644, 645, 654, 657, 659, 673, 688, 875, 892, 946, 1647, 1652, 1656; BAS 69, 72, 464/1; BS 30D, 56H, 91E, 91F, 93C, 93E, 155, 156, 316C, 316E, 410C, 1030, 8620; ECRM 85-1, 86-1, 87-1; IARM 13A; IMZ 1.85, 112, 156, 161, 171, 503; IPT 208Fe; JK 37; SRM C1151A, 13F, 16F, 30F, 73B, 133A, 160B, 343A, 361, 362, 363, 862, 1219, 1243, 1246, 1249, 1263, 1263A, 1413, 1763A, 2159, 3101A, 3107, 3109A, 3113, 3137, 3155, 3162A, 3163, 3169.

**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 — 501-676; BAS 72; BS HON-T, 91E, 91F, 93C, 93E, 155, 156; KMS HCS-001; NCS NS20035B; SRM 30F, 1219.

**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 93F 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 Valbruna, Italy.

**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.

**Certificate Number:** The unique identification number for this certificate of analysis is 93F-092115. 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  
**Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895**  
**Telephone: (281) 440-9396 Fax: (281) 440-4432 Website: [www.brammerstandard.com](http://www.brammerstandard.com)**  
Certificate Number 93F-092115 Page 5/7

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](http://www.brammerstandard.com)**  
**14603 Benfer Road**  
**Houston, Texas 77069-2895 USA**              **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

- 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 9001:2008    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 September 21, 2015.

Beau R. Brammer