

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS 410C

Certified Reference Material for Stainless Steel Grade 410 - UNS Number S41000

	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>0.0079</b>	0.0006		<b>Nb</b>	<b>0.0056</b>	0.0004
<b>As</b>	<b>0.0029</b>	0.0004		<b>Ni</b>	<b>0.352</b>	0.004
<b>C</b>	<b>0.131</b>	0.002		<b>O</b>	<b>0.0051</b>	0.0006
<b>Ca</b>	<b>0.0022</b>	0.0004		<b>P</b>	<b>0.0206</b>	0.0007
<b>Co</b>	<b>0.0185</b>	0.0007		<b>S</b>	<b>0.0051</b>	0.0003
<b>Cr</b>	<b>12.78</b>	0.05		<b>Si</b>	<b>0.366</b>	0.004
<b>Cu</b>	<b>0.084</b>	0.002		<b>Sn</b>	<b>0.0023</b>	0.0003
<b>Fe</b>	<b>[85.4]</b>	0.5		<b>Ti</b>	<b>0.0006</b>	0.0002
<b>Mn</b>	<b>0.381</b>	0.005		<b>V</b>	<b>0.042</b>	0.001
<b>Mo</b>	<b>0.055</b>	0.001		<b>W</b>	<b>0.0131</b>	0.0008
<b>N</b>	<b>0.039</b>	0.001				

	Reference Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	<b>Reference Values<sup>3,4</sup></b>	Reference Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>
<b>Mg</b>	<b>0.0003</b>	0.0002			

### Informational Values<sup>3,5</sup>

B (0.0001)      Pb (0.0001)      Sb (0.0002)      Ta (0.001)      Zr (0.0002)

<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> Reference Values are not certified and are provided for information only.

<sup>5</sup> Values in parentheses are not certified and are provided for information only.

Trace element information values for Cd, Ce, Cl, Ga, Ge, Hf, 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.

**Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895**  
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## BS 410C

\* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe
1	12	0.0065	4	0.0022	1	0.1285	14	0.0019	8	0.016233	4	12.749	10	0.0789	13	85.361
2	5	0.006967	9	0.002335	3	0.13	4	0.00208	3	0.0170	14	12.77	4	0.078933	16	85.61
3	3	0.0073	5	0.0025	1	0.130633	4	0.0021	4	0.017133	13	12.77533	3	0.0794	4	85.64667
4	14	0.0077	15	0.0035	1	0.130667	3	0.00225	12	0.0172	13	12.77867	14	0.0804	16	85.65667
5	4	0.008067	5	0.003533	1	0.131	4	0.002333	5	0.017233	3	12.78	5	0.0804	16	85.6633
6	4	0.008167	5	0.003567	1	0.1322	4	0.002933	5	0.017933	4	12.79333	10	0.080967	10	85.70333
7	3	0.0084	12	0.0037	1	0.132667			5	0.018333	13	12.795	3	0.081	3	85.72
8	4	0.008567	5	0.0037	1	0.1329			3	0.0187	3	12.80333	4	0.082133	16	85.74
9	3	0.009			1	0.133333			4	0.018767	10	12.81	5	0.082567		
10					1	0.134			14	0.019033	10	12.82	4	0.0847		
11					3	0.135			4	0.0193	4	12.82667	4	0.084767		
12									4	12.82933	4	0.086567				
13									3	12.90	8	0.087267				
Average		0.00787		0.00289		0.1313		0.002187		0.01845		12.783		0.0836		85.45
Std dev		0.00046		0.00021		0.0025		0.000075		0.00058		0.042		0.0017		0.38
H		0.00060		0.00041		0.0025		0.00037		0.0009		0.075		0.0019		0.45
U <sub>1</sub>		0.00076		0.00046		0.0036		0.00038		0.0011		0.086		0.0026		0.59
t-statistic		2.31		2.36		2.23		2.57		2.23		2.18		2.18		2.36
U <sub>2</sub>		0.0017		0.0011		0.0079		0.0010		0.0023		0.19		0.0056		1.39
U <sub>3</sub>		0.00058		0.00038		0.0024		0.00039		0.00071		0.052		0.0016		0.49
<b>Certified</b>		<b>0.0079</b>		<b>0.0029</b>		<b>0.131</b>		<b>0.0022</b>		<b>0.0185</b>		<b>12.78</b>		<b>0.084</b>		<b>[85.4]</b>
<b>Uncertainty</b>		<b>0.0006</b>		<b>0.0004</b>		<b>0.002</b>		<b>0.0004</b>		<b>0.0007</b>		<b>0.05</b>		<b>0.002</b>		<b>0.5</b>
Tolerance		0.0017		0.0011		0.008		0.0010		0.0023		0.19		0.006		1.4

Analysis	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	S
1	8	0.372333	3	0.050367	2	0.037	5	0.005067	3	0.34	2	0.003933	12	0.0185	3	0.0046
2	4	0.373	14	0.051967	2	0.037067	4	0.0052	3	0.340333	2	0.004567	4	0.019167	1	0.00485
3	3	0.374	4	0.053033	2	0.03725	4	0.005467	4	0.347667	2	0.004767	3	0.0200	3	0.0050
4	4	0.3744	4	0.053367	2	0.037867	3	0.0058	14	0.348667	2	0.005025	5	0.020267	1	0.005
5	4	0.376667	7	0.053467	2	0.038433	14	0.005833	12	0.3500	2	0.005037	3	0.0203	1	0.0052
6	3	0.377	5	0.0536	2	0.039167	5	0.0060	4	0.350567	2	0.0053	5	0.020367	1	0.0053
7	10	0.38	12	0.0540	2	0.039367	5	0.006267	3	0.351			10	0.0204	1	0.005333
8	10	0.381333	10	0.0546	2	0.040133	5	0.006333	4	0.353	4	0.020567	12	0.0055		
9	5	0.3817	3	0.055			4	0.006633	4	0.3533	7	0.020667	1	0.0057		
10	4	0.3823	4	0.055133			12	0.0068	5	0.353333	4	0.0213	1	0.005713		
11	4	0.382667	10	0.0557			4	0.006833	4	0.355	5	0.021433	1	0.005767		
12	14	0.386467	3	0.0558					8	0.356333	4	0.021667	1	0.0062		
13	4	0.389	4	0.055833					4	0.361667			14	0.0226		
14	3	0.39	4	0.055933									3	0.023333		
15			5	0.056333												
Average		0.3808		0.0549		0.03876		0.00562		0.3517		0.00505		0.02064		0.00508
Std dev		0.0062		0.0014		0.00086		0.00028		0.0052		0.00019		0.00067		0.00012
H		0.0049		0.0015		0.0013		0.00052		0.0046		0.00050		0.0009		0.00050
U <sub>1</sub>		0.0079		0.0020		0.0015		0.00059		0.0070		0.00053		0.0011		0.00052
t-statistic		2.16		2.14		2.36		2.23		2.18		2.57		2.16		2.20
U <sub>2</sub>		0.017		0.0044		0.0036		0.0013		0.015		0.0014		0.0025		0.0011
U <sub>3</sub>		0.0046		0.0011		0.0013		0.00040		0.0042		0.00056		0.00066		0.00033
<b>Certified</b>		<b>0.381</b>		<b>0.055</b>		<b>0.039</b>		<b>0.0056</b>		<b>0.352</b>		<b>0.0051</b>		<b>0.0206</b>		<b>0.0051</b>
<b>Uncertainty</b>		<b>0.005</b>		<b>0.001</b>		<b>0.001</b>		<b>0.0004</b>		<b>0.004</b>		<b>0.0006</b>		<b>0.0007</b>		<b>0.0003</b>
Tolerance		0.017		0.004		0.004		0.0013		0.015		0.0014		0.0025		0.0011

## BS 410C

\* Code for method

Certified values listed as weight percent

Analysis	*	Si	*	Sn	*	Ti	*	V	*	W
1	3	0.35	5	0.002167	5	0.0005	4	0.040067	14	0.0111
2	6	0.350667	12	0.0022	5	0.00051	14	0.040833	12	0.0112
3	4	0.355667	5	0.002233	12	0.00065	4	0.041833	4	0.012867
4	12	0.3600	4	0.002367	5	0.00078	7	0.041933	4	0.013067
5	4	0.360333	5	0.002367	4	0.001267	4	0.042367	4	0.013133
6	3	0.362	5	0.0024	3	0.0014	5	0.0424	5	0.013633
7	3	0.364	5	0.0025	4	0.001443	4	0.042733	5	0.014233
8	4	0.364667	3	0.003	4	0.001667	3	0.0432	3	0.0143
9	14	0.366333					3	0.0433	4	0.014733
10	10	0.367					10	0.0435		
11	10	0.367					10	0.043933		
12	4	0.370333					3	0.045		
13	5	0.375667					4	0.046433		
14	4	0.380067					12	0.0470		
15	4	0.380333								
Average		0.3663		0.00231		0.000634		0.0419		0.01314
Std dev		0.0058		0.00018		0.000073		0.0011		0.00067
H		0.0048		0.00038		0.00025		0.0013		0.0007
U <sub>1</sub>		0.0075		0.00042		0.00026		0.0017		0.0010
t-statistic		2.14		2.36		2.36		2.16		2.31
U <sub>2</sub>		0.016		0.0010		0.00063		0.0037		0.0023
U <sub>3</sub>		0.0041		0.00035		0.00022		0.0010		0.00077
<b>Certified</b>		<b>0.366</b>		<b>0.0023</b>		<b>0.0006</b>		<b>0.042</b>		<b>0.0131</b>
<b>Uncertainty</b>		<b>0.004</b>		<b>0.0003</b>		<b>0.0002</b>		<b>0.001</b>		<b>0.0008</b>
<b>Tolerance</b>		0.016		0.0010		0.0006		0.004		0.0023

## BS 410C

\* Code for method

Reference values listed as weight percent

Analysis	*	Mg
1	5	0.000147
2	8	0.000147
3	3	0.0002
4	5	0.00024
5	4	0.00028
6	14	0.00029
7	5	0.0003
8	4	0.000367
9	5	0.0004
10	12	0.00052
Average		0.000310
Std dev		0.000021
H		0.00021
U <sub>1</sub>		0.00022
t-statistic		2.26
U <sub>2</sub>		0.00049
U <sub>3</sub>		0.00015
<b>Reference</b>		<b>(0.0003)</b>
(Uncertainty)		(0.0002)
(Tolerance)		(0.0005)

**BS 410C** \* Code for method Informational values listed as weight percent

Analysis	*	B	*	Pb	*	Sb	*	Ta	*	Zr
1	5	0.000046	5	0.0000133	9	0.00002	5	0.0008	5	0.00001
2	12	0.000056	12	0.000025	5	0.0005			5	0.0000767
3	7	0.000103	5	0.000033	5	0.000533			5	0.000113
4	3	0.00012	5	0.00006	5	0.0006			4	0.0005
5	14	0.00017	3	0.0001	5	0.0006			4	0.000733
6			5	0.000207	5	0.000633			3	0.0009
7			14	0.00039	12	0.00070			12	0.0011
8									14	0.0011
9									4	0.0011
Average		0.0001020		0.0001217		0.000224		0.00080		0.000187
Std dev		0.0000088		0.0000083		0.000033		0.00021		0.000040
H		0.00018		0.00018		0.00020		0.00027		0.00019
U <sub>1</sub>		0.00018		0.00018		0.00020		0.00034		0.00020
t-statistic		2.78		2.45		2.45		12.71		2.31
U <sub>2</sub>		0.00049		0.00044		0.00050		0.0043		0.00046
U <sub>3</sub>		0.00022		0.00017		0.00019		0.0043		0.00015
(Informational)		(0.0001)		(0.0001)		(0.0002)		(0.001)		(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<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 it's 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.

**BS 410C** \* Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Cd	*	Ce	*	Cl	*	Ga	*	Ge	*	Hf	*	K	*	La	*	Na	*	Re	
1	4	2	4	3	12	0.10	12	15	5	12	12	0.19	12	0.50	4	2	12	0.30	12	0.67	
2							5	20	5	12										5	2.0
3							5	20	5	13										5	2.1
4							5	20	12	15										5	2.3

Analysis	*	Zn
1	4	2
2	12	5.0

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

<u>Laboratory</u>	<u>Location</u>	<u>Registrar</u>	<u>Accreditation</u>
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Dirats Laboratories	Westfield, MA	ACCLASS	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Exova	Glendale Heights, IL	A2LA	17025
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Exova	Glendale Heights, IL	A2LA	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	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

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

**Traceability:** The following Certified Reference Materials were used to validate the analytical data listed on pages 2-4 — AR 646, 654, 657, 676, 875, 1651, 1653, 1656; BAS 087/1, 431/1, 435, 456, 460, 464/1, 475; BS CSN 2-1, CSN 4, SS4951, 0021, 0022, 0121P, 0122P, 30D, 56H, 61G, 89D, 98, 410B, 1030; ECRM 037/1, 096/1, 85/1, 86/1, 87/1, 237/2, 327/2; IARM 9B, 35H, 41C, 42B, 242A; IMZ 1.8/3, 112, 119, 159; JK 37, 47; SRM 13F, 30F, 55D, 72F, 73B, 133A, 133B, 160B, 361, 362, 363, 410G, 1246, 1263A, 1763, 1766, 3108, 3109A, 3110, 3127A, 3161A, 3163, 3168A, 3169; 12x349, 12x356, 12x357, 12x10180; 501-102, 501-320, 501-501, 501-502, 501-503, 501-504, 501-644, 501-673, 501-676, 501-677, 501-993, 502-102, 502-194, 502-197.

**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 — BS CSN 2-1, CSN 4, SS4951, 0021, 0022, 0121P, 0122P, 89D, 98, 410B; BAS 475; ECRM 096/1, 327/2, 285/4, 285/1; KMS HOCS-001; 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 410C 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 Gloria Material Technology Corp., Taiwan

**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 410C-041414. 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

Fax: (281) 440-4432

Web: [www.brammerstandard.com](http://www.brammerstandard.com)

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 April 14, 2014.

Beau R. Brammer