

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS 304

Certified Reference Material for Stainless Steel Grade 304L - UNS Number S30403

	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>0.0022</b>	0.0004		<b>Sn</b>	<b>0.0116</b>	0.0006
<b>C</b>	<b>0.018</b>	0.001		<b>V</b>	<b>0.087</b>	0.002
<b>Co</b>	<b>0.153</b>	0.002		<b>W</b>	<b>0.040</b>	0.001
<b>Cr</b>	<b>18.01</b>	0.06				
<b>Cu</b>	<b>0.474</b>	0.004				
<b>Fe</b>	<b>[70.5]</b>	0.3				
<b>Mn</b>	<b>1.775</b>	0.009				
<b>Mo</b>	<b>0.237</b>	0.003				
<b>N</b>	<b>0.063</b>	0.002				
<b>Nb</b>	<b>0.0054</b>	0.0004				
<b>Ni</b>	<b>8.20</b>	0.03				
<b>O</b>	<b>0.0083</b>	0.0005				
<b>P</b>	<b>0.039</b>	0.001				
<b>S</b>	<b>0.0214</b>	0.0006				
<b>Si</b>	<b>0.451</b>	0.004				

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

As (0.005)	B (0.0005)	Ca (0.001)	Mg (0.0003)	Pb (0.0003)
Sb (0.002)	Ti (0.0004)	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, Ga, Ge, Pt, Re, Ta, 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 304

\* Code for method Certified values listed as weight percent

Analysis	*	Al	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo
1	5	0.000927	1	0.017	4	0.14	10	17.67333	4	0.448667	16	[70.33333]	4	1.733667	4	0.223333
2	3	0.00215	3	0.0171	12	0.1450	3	17.80	14	0.449333	16	[70.3633]	8	1.754333	4	0.231
3	3	0.0026	1	0.017233	3	0.146	13	17.81	10	0.451667	14	[70.41]	4	1.756483	3	0.233
4	4	0.0028	1	0.017283	14	0.151	13	17.83467	3	0.46	16	[70.42]	3	1.756667	4	0.23385
5	14	0.002833	1	0.017367	4	0.152333	10	17.91	10	0.466	16	[70.4875]	4	1.756667	4	0.234333
6	4	0.003333	1	0.017433	4	0.152667	3	17.92	3	0.4662	4	70.53333	10	1.76	14	0.236
7	4	0.0038	1	0.017767	3	0.152667	4	17.93467	4	0.470	10	70.56	3	1.76488	4	0.2366
8			1	0.018887	3	0.1539	10	17.94	4	0.4709	13	70.59433	14	1.77	10	0.238
9			1	0.0195	4	0.154867	4	17.95267	4	0.472667	3	70.65333	10	1.77	4	0.23933
10			1	0.019567	8	0.156333	3	17.96	3	0.473333	16	[70.70667]	3	1.7775	3	0.24
11			1	0.02028	3	0.15675	4	17.98	5	0.474167	10	71.33333	4	1.788667	4	0.241667
12			3	0.020675	10	0.158	3	17.9949	4	0.478			3	1.79	5	0.244
13			1	0.021167	4	0.158	4	18.02	4	0.478183			4	1.80	7	0.245
14					4	0.1586	4	18.04	4	0.48			4	1.800633	3	0.246
15					4	0.161667	4	18.10013	8	0.482			4	1.817	3	0.24716
16					10	0.161667	14	18.12333	4	0.487			10	1.83	5	0.247667
17							10	18.20577	3	0.49025					12	0.2500
18									10	0.499						
19									12	0.5100						
Average		0.00217		0.01843		0.1535		18.0074		0.4743		70.548		1.7747		0.2373
Std dev		0.00010		0.00071		0.0032		0.0026		0.0045		0.056		0.0052		0.0036
H		0.00040		0.0009		0.0028		0.11		0.0058		0.43		0.015		0.0037
U <sub>1</sub>		0.00041		0.0011		0.0043		0.11		0.0073		0.43		0.016		0.0052
t-statistic		2.45		2.18		2.13		2.12		2.10		2.23		2.13		2.12
U <sub>2</sub>		0.0010		0.0025		0.0091		0.24		0.015		0.97		0.034		0.011
U <sub>3</sub>		0.00038		0.00070		0.0023		0.057		0.0035		0.29		0.0085		0.0027
<b>Certified</b>		<b>0.0022</b>		<b>0.018</b>		<b>0.153</b>		<b>18.01</b>		<b>0.474</b>		<b>[70.5]</b>		<b>1.775</b>		<b>0.237</b>
<b>Uncertainty</b>		<b>0.0004</b>		<b>0.001</b>		<b>0.002</b>		<b>0.06</b>		<b>0.004</b>		<b>0.3</b>		<b>0.009</b>		<b>0.003</b>
Tolerance		0.0010		0.002		0.009		0.24		0.015		1.0		0.034		0.011

Analysis	*	N	*	Nb	*	Ni	*	O	*	P	*	S	*	Si	*	Sn
1	2	0.0588	14	0.004033	4	7.990667	2	0.007473	12	0.0350	1	0.018467	10	0.426	3	0.010
2	2	0.060667	5	0.0048	10	8.04	2	0.0078	4	0.035167	3	0.019	6	0.43	4	0.010267
3	2	0.06177	5	0.0050	4	8.065667	2	0.00781	3	0.035667	1	0.019167	10	0.434	3	0.011
4	2	0.062667	4	0.005147	4	8.088333	2	0.007933	5	0.036067	3	0.0205	4	0.437667	5	0.0114
5	2	0.0627	5	0.005253	4	8.105367	2	0.00814	10	0.037	1	0.0205	4	0.442667	5	0.0115
6	2	0.062767	5	0.0058	14	8.116667	2	0.00841	4	0.037	10	0.021	4	0.445	3	0.011675
7	2	0.064025	10	0.0069	13	8.118667	2	0.008433	10	0.037133	1	0.021353	14	0.445333	5	0.012133
8	2	0.064967	4	0.0072	3	8.12	2	0.008733	3	0.0381	1	0.021633	4	0.448667	4	0.012333
9	2	0.065467	4	0.0077	10	8.123333	2	0.0092	4	0.0394	1	0.021703	3	0.45	4	0.012667
10	2	0.065667	3	0.007775	4	8.1525	2	0.0098	7	0.039733	1	0.021833	10	0.452333	5	0.012733
11	2	0.066333			4	8.153333			4	0.040067	1	0.021833	4	0.453	4	0.012867
12	2	0.068277			3	8.17			4	0.0401	1	0.021967	4	0.453333	12	0.0130
13					3	8.18			10	0.040333	1	0.022	6	0.453667		
14					10	8.189767			14	0.0405	3	0.0222	4	0.45495		
15					4	8.24			3	0.041	1	0.022617	3	0.45637		
16					3	8.24816			4	0.0413	1	0.024	3	0.45925		
17					10	8.34			10	0.0414			5	0.4635		
18													3	0.464333		
19													4	0.469		
Average		0.0632		0.00539		8.2000		0.00826		0.0393		0.02141		0.4511		0.01160
Std dev		0.0018		0.00027		0.0036		0.00029		0.0013		0.00070		0.0049		0.00048
H		0.0017		0.00054		0.054		0.00064		0.0013		0.0010		0.0056		0.00074
U <sub>1</sub>		0.0025		0.00061		0.054		0.00070		0.0018		0.0012		0.0074		0.00088
t-statistic		2.20		2.26		2.12		2.26		2.12		2.13		2.10		2.20
U <sub>2</sub>		0.0055		0.0014		0.12		0.0016		0.0038		0.0025		0.016		0.0019
U <sub>3</sub>		0.0016		0.00043		0.028		0.00050		0.00090		0.00064		0.0036		0.00056
<b>Certified</b>		<b>0.063</b>		<b>0.0054</b>		<b>8.20</b>		<b>0.0083</b>		<b>0.039</b>		<b>0.0214</b>		<b>0.451</b>		<b>0.0116</b>
<b>Uncertainty</b>		<b>0.002</b>		<b>0.0004</b>		<b>0.03</b>		<b>0.0005</b>		<b>0.001</b>		<b>0.0006</b>		<b>0.004</b>		<b>0.0006</b>
Tolerance		0.005		0.0014		0.12		0.0016		0.004		0.0025		0.016		0.0019

**BS 304** \* Code for method Certified values listed as weight percent

Analysis	*	V	*	W
1	4	0.079	3	0.033233
2	4	0.08	4	0.0339
3	3	0.084	12	0.0350
4	10	0.0844	10	0.035167
5	7	0.085067	14	0.035867
6	4	0.086033	5	0.035933
7	4	0.0864	5	0.038967
8	3	0.086933	4	0.0399
9	3	0.088125	10	0.04
10	3	0.089	4	0.040233
11	14	0.089367	3	0.041
12	4	0.090033	4	0.0413
13	5	0.0934	10	0.041333
14	4	0.097	3	0.0420
15	12	0.1000	3	0.0422
16			4	0.045533
17			5	0.0495
Average		0.0872		0.0402
Std dev		0.0023		0.0013
H		0.0020		0.0013
U <sub>1</sub>		0.0030		0.0019
t-statistic		2.14		2.12
U <sub>2</sub>		0.0065		0.0040
U <sub>3</sub>		0.0017		0.0010
<b>Certified</b>		<b>0.087</b>		<b>0.040</b>
<b>Uncertainty</b>		<b>0.002</b>		<b>0.001</b>
<b>Tolerance</b>		0.006		0.004

**BS 304** \* Code for method Informational values listed as weight percent

Analysis	*	As	*	B	*	Ca	*	Mg	*	Pb	*	Sb	*	Ti	*	Zr
1	12	0.0047	5	0.00011	3	0.00094	5	0.000153	5	0.000012	12	0.0015	3	0.0001	5	0.000127
2	5	0.005433	12	0.00017	12	0.0014	12	0.00027	12	0.000015	5	0.0020	5	0.00023	3	0.002175
3			3	0.000655			3	0.000588	3	0.000975			12	0.00030		
4			3	0.0010									3	0.000925		
Average		0.005		0.00048		0.0012		0.00034		0.00033		0.002		0.0004		0.0012
Std dev		0.074		0.00089		0.0070		0.00047		0.00046		0.014		0.0011		0.0068
H		0.001		0.00027		0.0003		0.00026		0.00025		0.000		0.00026		0.0003
U <sub>1</sub>		0.074		0.00093		0.0070		0.00054		0.00053		0.014		0.0011		0.0068
t-statistic		12.71		3.18		12.71		4.30		4.30		12.71		3.18		12.71
U <sub>2</sub>		0.94		0.0029		0.089		0.0023		0.0023		0.18		0.0036		0.086
U <sub>3</sub>		0.67		0.0015		0.063		0.0013		0.0013		0.13		0.0018		0.061
<b>(Informational)</b>		<b>(0.005)</b>		<b>(0.0005)</b>		<b>(0.001)</b>		<b>(0.0003)</b>		<b>(0.0003)</b>		<b>(0.002)</b>		<b>(0.0004)</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 304** \* Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis *	Bi	* Ga	* Ge	* Pt	* Re	* Ta	* Zn
1	12 0.01	12 23	12 21	12 0.11	12 0.50	12 0.48	12 0.61

#### 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  
NSL Analytical  
Laboratory Testing, Inc.  
Dirats Laboratories  
Luvak Inc.  
Elemental Analysis, Inc.  
National Analysis Center For Iron And Steel  
Exova  
Instytut Metalurgii Zelaza

#### Location

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

#### Registrar

A2LA  
A2LA  
ACCLASS  
PRI/Nadcap  
ACCLASS  
PRI/Nadcap  
A2LA  
CNAS  
A2LA  
PCA

#### Accreditation

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

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: 12X356, 12X357, 12X3255, 12X43400, 12X72M24, 13X12855, 13X15035, 13X30403A, 13X43100, 13XNCS3, 13XNSA11, 215XHC3, 215XHC5; 501-147, 501-257, 501-320, 501-501, 501-502, 501-503, 501-504, 501-644, 501-646, 501-675, 501-676, 501-991, 501-993, 502-257, 502-402, 502-416; AR 644, 646, 654, 657, 869, 875, 878, 1656; BAS 55, 65, 317, 409, 431/1, 464/1; BS CA304-3, 81E, 81F, 81G, 81P, 81V-1, 192A, 303, 3951, 4829A; CKD 166A, 181; ECRM 85, 86, 87, 284/2; IARM 6G, 241B, 289A; IMZ 112, 124, 504; IPT 208; JK 37; JSS 655-13; NCS NS11022; SRM 55D, 101C, 101D, 101E, 101G, 121D, 160B, 343A, 361, 362, 363, 365, 1162, 1170B, 1225, 1246, 1249, 1261, 1263A, 1264A, 1413, 1763A.

**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, 502-257, 502-416; BAS 431/1; BS CA304-3; 81E, 81G, 81P, 81V-1, 192A; ECRM 284-2; IARM 289A; NCS NS11022; SRM 101G.

**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 304 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 Chandan Steel Limited; Mumbai, India.

**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 304-030315. 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

- 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 March 3, 2015.

Beau R. Brammer