

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 188B

Certified Reference Material for Stainless Steel Grade A286 - UNS Number S66286

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.168	0.003		Si	0.006
As	0.0045	0.0006		Sn	0.0004
B	0.0047	0.0004		Ti	0.02
C	0.046	0.001		V	0.005
Co	0.274	0.005		W	0.002
Cr	14.32	0.08			
Cu	0.120	0.003			
Fe	55.8	0.2			
Mn	0.247	0.009			
Mo	1.30	0.02			
N	0.0021	0.0003			
Nb	0.099	0.004			
Ni	24.81	0.09			
O	0.0006	0.0002			
P	0.016	0.001			

Informational Values^{3,4}

Ca (0.00003)	Mg (0.0005)	Pb (0.0001)	S (0.0007)	Sb (0.0006)
Ta (0.00003)	Zr (0.002)			

¹ 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.

² 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.

³ Values are given in weight percent. Values in brackets are reported by difference.

⁴ Values in parentheses are not certified and are provided for information only.

Trace element information values for Bi, Cl, Ga, Ge, K, Na, Pt, 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.

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* Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe
1	10	0.144667	5	0.0035	5	0.004067	1	0.0433	10	0.23	4	14.11907	4	0.1132	13	55.27533
2	3	0.148667	4	0.003533	12	0.0042	1	0.043867	12	0.2500	14	14.23333	14	0.114667	16	[55.53333]
3	4	0.152667	9	0.003767	4	0.004233	1	0.0439	5	0.266667	3	14.23667	4	0.116333	16	[55.6]
4	10	0.16	4	0.004167	4	0.0045	1	0.044833	3	0.269	3	14.24	3	0.119	10	55.72
5	4	0.162667	3	0.0042	5	0.0045	1	0.045033	14	0.27	10	14.24	8	0.119667	10	55.75667
6	4	0.163333	15	0.00501	3	0.00481	1	0.045333	3	0.27	4	14.2667	4	0.12	16	[55.77333]
7	5	0.166533	5	0.0051	7	0.00501	1	0.045667	4	0.274333	10	14.26333	5	0.120567	3	55.90667
8	14	0.166667	12	0.0055	4	0.005133	3	0.047	4	0.274733	4	14.325	4	0.120667	4	55.98333
9	10	0.169	5	0.0057	14	0.005133	1	0.047	4	0.276	13	14.34467	5	0.121467	14	56.0
10	4	0.169167			4	0.005333	3	0.0479	8	0.277	4	14.38333	4	0.122667	16	[56.14]
11	3	0.17					1	0.049033	4	0.28	3	14.40	10	0.125	4	56.2
12	4	0.170667					1	0.04926	10	0.282	4	14.40667	10	0.126333	16	[56.40593]
13	4	0.171667					1	0.049275	4	0.284333	4	14.40967	4	0.1264		
14	5	0.1723							10	0.291667	4	14.45333	3	0.127		
15	3	0.18							4	0.2930	10	14.46333	12	0.1280		
16	12	0.2000							3	0.293667			3	0.13		
17									5	0.2952			10	0.133333		
Average		0.1679		0.00454		0.00472		0.0464		0.2739		14.324		0.1202		55.846
Std dev		0.0040		0.00027		0.00016		0.0018		0.0045		0.043		0.0030		0.073
H		0.0030		0.00051		0.00052		0.0015		0.0041		0.086		0.0025		0.31
U ₁		0.0050		0.00058		0.00054		0.0023		0.0061		0.096		0.0039		0.32
t-statistic		2.13		2.31		2.26		2.18		2.12		2.14		2.12		2.20
U ₂		0.011		0.0013		0.0012		0.0050		0.013		0.21		0.0083		0.70
U ₃		0.0027		0.00044		0.00039		0.0014		0.0032		0.053		0.0020		0.20
Certified		0.168		0.0045		0.0047		0.046		0.274		14.32		0.120		55.8
Uncertainty		0.003		0.0006		0.0004		0.001		0.005		0.08		0.003		0.2
Tolerance		0.011		0.0013		0.0012		0.005		0.013		0.21		0.008		0.7

Analysis	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	Si
1	10	0.215667	4	1.25	2	0.0016	4	0.089333	3	24.59	2	0.00017	12	0.0120	4	0.236633
2	4	0.231667	14	1.276667	2	0.00177	4	0.0958	10	24.65667	2	0.000173	10	0.0138	4	0.248333
3	14	0.232667	3	1.28	2	0.001833	5	0.097367	3	24.7	2	0.000433	5	0.01563	14	0.250667
4	4	0.234333	4	1.287	2	0.001967	4	0.098833	6	24.71733	2	0.00044	4	0.016333	3	0.258
5	4	0.235667	4	1.288333	2	0.002167	14	0.0996	3	24.74667	2	0.00049	3	0.0168	10	0.26
6	8	0.237333	7	1.293	2	0.002233	12	0.1000	10	24.75	2	0.000567	14	0.016967	10	0.266667
7	4	0.2397	4	1.294667	2	0.002233	4	0.101367	4	24.77	2	0.000667	10	0.017	10	0.268
8	3	0.24	4	1.296667	2	0.002297	5	0.102067	4	24.78	2	0.000933	7	0.0172	3	0.270
9	10	0.243	4	1.31	2	0.0024	4	0.103667	13	24.79567	2	0.000933	5	0.017633	4	0.27
10	4	0.2467	10	1.316667	2	0.002667	4	0.1041	4	24.83667	2	0.001167	4	0.017667	12	0.2700
11	3	0.251	10	1.320			7	0.106667	4	24.93333	2	0.002	4	0.017833	3	0.271333
12	5	0.251267	3	1.32			10	0.106667	14	24.93333			3	0.018	6	0.271667
13	5	0.2546	3	1.326667			10	0.107	10	24.95333			4	0.018267	4	0.274
14	4	0.255	4	1.327333			3	0.11	4	25.00833			4	0.018633	4	0.275567
15	4	0.27	4	1.339633					4	25.075			4	0.0188	5	0.2768
16	12	0.2750	10	1.35									3	0.0195	4	0.282
17	3	0.278													4	0.293333
18	10	0.28														
Average		0.2468		1.300		0.00211		0.0994		24.806		0.000600		0.01634		0.2655
Std dev		0.0041		0.010		0.00019		0.0030		0.060		0.000070		0.00085		0.0043
H		0.0039		0.012		0.00039		0.0022		0.14		0.00027		0.0009		0.0040
U ₁		0.0057		0.016		0.00043		0.0037		0.15		0.00028		0.0012		0.0059
t-statistic		2.11		2.13		2.26		2.16		2.14		2.23		2.13		2.12
U ₂		0.012		0.034		0.0010		0.0080		0.33		0.00063		0.0026		0.012
U ₃		0.0028		0.0080		0.00031		0.0021		0.085		0.00019		0.00070		0.0030
Certified		0.247		1.30		0.0021		0.099		24.81		0.0006		0.016		0.266
Uncertainty		0.009		0.02		0.0003		0.004		0.09		0.0002		0.001		0.006
Tolerance		0.012		0.03		0.0010		0.008		0.33		0.0006		0.003		0.012

BS 188B * Code for method Certified values listed as weight percent

Analysis	*	Sn	*	Ti	*	V	*	W
1	9	0.0037	4	2.106	10	0.2400	10	0.034
2	12	0.0041	4	2.136667	12	0.240	12	0.0350
3	3	0.0041	4	2.17	10	0.246667	4	0.037
4	5	0.004667	4	2.172333	4	0.257333	4	0.0402
5	4	0.0047	10	2.18	14	0.258333	4	0.041467
6	5	0.004897	3	2.18	5	0.258367	3	0.0416
7	4	0.004933	7	2.183333	4	0.259	14	0.041733
8	5	0.005033	3	2.183333	3	0.26	4	0.042333
9	5	0.005533	10	2.2	10	0.262	4	0.044533
10	4	0.007	3	2.20	3	0.264	7	0.044867
11			4	2.201667	4	0.264667	5	0.044867
12			4	2.2184	3	0.265	10	0.045
13			4	2.230	4	0.266667	4	0.0454
14			10	2.3	7	0.267	5	0.052233
15					5	0.2707		
16					4	0.2708		
17					4	0.272		
Average		0.00510		2.1953		0.2638		0.0425
Std dev		0.00021		0.0071		0.0041		0.0015
H		0.00054		0.018		0.0040		0.0014
U ₁		0.00057		0.019		0.0058		0.0020
t-statistic		2.26		2.16		2.12		2.16
U ₂		0.0013		0.042		0.012		0.0044
U ₃		0.00041		0.011		0.0030		0.0012
Certified		0.0051		2.20		0.264		0.043
Uncertainty		0.0004		0.02		0.005		0.002
Tolerance		0.0013		0.04		0.012		0.004

BS 188B * Code for method Informational values listed as weight percent

Analysis	*	Ca	*	Mg	*	Pb	*	S	*	Sb	*	Ta	*	Zr
1	12	0.000017	12	0.00013	12	0.0000022	5	0.000033	5	0.00060	12	0.000034	3	0.0018
2	3	0.00024	4	0.0002	4	0.0002667	1	0.000267	12	0.00060			12	0.0021
3	4	0.000433	3	0.00021			1	0.000367					5	0.0021
4	4	0.0009	5	0.001367			1	0.00042						
5	4	0.001767					1	0.0007						
6							10	0.0008						
7							1	0.001067						
8							3	0.0017						
Average		0.000028		0.00048		0.000134		0.0007		0.0006		0.0000340		0.002
Std dev		0.000015		0.00089		0.000080		0.0012		0.0020		0.0000034		0.014
H		0.00017		0.00026		0.00020		0.0003		0.0003		0.00017		0.000
U ₁		0.00017		0.00093		0.00022		0.0013		0.0020		0.00017		0.014
t-statistic		2.78		3.18		12.71		2.36		12.71		12.71		4.30
U ₂		0.00048		0.0030		0.0028		0.0030		0.026		0.0022		0.060
U ₃		0.00021		0.0015		0.0019		0.0011		0.018		0.0022		0.034
(Informational)		(0.00003)		(0.0005)		(0.0001)		(0.0007)		(0.0006)		(0.00003)		(0.002)

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_L), calculated from its standard deviation (S_L) and its uncertainty estimate (U_L), is used as the weight (W_L) for its mean (M_L). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U_1 is the combined uncertainty from homogeneity and labs. U_2 is U_1 multiplied by the coverage factor (95 % t-statistic). U_3 is U_2 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_3 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	* Code for analytical method										Trace analysis listed as mg/kg (ppm)				
	* Bi	* Cl	* Ga	* Ge	* K	* Na	* Pt	* Re	* Zn						
1	12 0.01	12 0.033	12 27	5 26	12 0.23	12 0.33	12 0.15	12 0.76	12 0.13						
2			5 32	5 27				5 1.9							
3			5 32	5 27				5 1.9							
4			5 32	12 30				5 2.0							

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

<u>Laboratory</u>	<u>Location</u>	<u>Registrar</u>	<u>Accreditation</u>
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
LECO Corporation	St. Joseph, MI	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Dirats Laboratories	Westfield, MA	ACCLASS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
Exova	Glendale Heights, IL	A2LA	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, 13X14212, 13X21800, 13X31254; 501-320, 504-501, 501-502, 501-503, 501-644, 501-646, 501-675, 501-676, 501-991, 501-992, 501-993, 502-197, 502-257, 502-348, 502-402, 502-414, 502-868, 502-873, 502-874; AR 644, 654, 673, 688, 875, 892, 1647, 1652, 1652; BAS 434, 464/1; BS HH5196A, HON-T, SS1962, 30D, 56H, 187D, 188, 189A, 316C, 316D, 316E, 410C, 451, 718C, 825E, 925, 1030, 2931; CKD 165A, 183A; DSZU CA01A; ECRM 096-1, 85-1, 86-1, 87-1, 299-1; IARM 26A; IMZ 1.85, 74, 76, 112; IPT 208; JK 37; KMS LCSON-001; NCS NS11022; SRM C1288, 101D, 101E, 101G, 160B, 348, 348A, 361, 362, 363, 365, 866, 868, 1230, 1246, 1249, 1263A, 1264A, 1269, 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; BS HH5196A, HON-T, SS1962, 188, 825E, 925; ECRM 096-1, 299-1; DSZU CA01A; KMS LCSNON-001; NCS NS11022; SRM C1288, 868, 1230.

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 188B 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 Carpenter Technology Corporation; Reading, PA.

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 188B-121415. You may obtain information

Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895
Telephone: (281) 440-9396 Fax: (281) 440-4432 Website: www.brammerstandard.com
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on revisions of certificates from the internet at 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. **Phone: (281) 440-9396** **Web: www.brammerstandard.com**
14603 Benfer Road
Houston, Texas 77069-2895 USA **Fax: (281) 440-4432** **Email: 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

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

Other useful documents available from NIST, U.S. Department of Commerce, Gaithersburg, MD 20899.

NIST Special Publication 260-100, Handbook for SRM Users

Certified by: _____ on December 14, 2015.

Beau R. Brammer