

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 431

Certified Reference Material for Stainless Steel Grade 431 - UNS Number S43100

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
Al	0.0019	0.0005		P	0.0232	0.0007
As	0.0038	0.0004		S	0.0047	0.0003
B	0.0003	0.0001		Sb	0.0011	0.0004
C	0.146	0.002		Si	0.393	0.008
Ca	0.0007	0.0003		Sn	0.0134	0.0008
Co	0.050	0.002		Ti	0.0007	0.0003
Cr	15.8	0.1		V	0.062	0.002
Cu	0.282	0.003		W	0.012	0.001
Fe	80.2	0.3				
Mn	0.579	0.004				
Mo	0.092	0.002				
N	0.049	0.001				
Nb	0.034	0.001				
Ni	2.25	0.01				
O	0.0059	0.0004				

Informational Values^{3,4}

Mg (0.0002)

Zr (0.001)

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, Pb, 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 431 * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Co	*	Cr [#]	*	Cu
1	5	0.0014	3	0.003	12	0.00015	1	0.137333	4	0.0004	3	0.0439	13	15.676	12	0.2400
2	4	0.001567	4	0.0033	5	0.000193	3	0.14	4	0.0007	12	0.0450	4	15.716	3	0.245333
3	12	0.0020	12	0.0034	3	0.0002	1	0.141667	12	0.00070	4	0.045133	10	15.72333	10	0.256667
4	4	0.0021	5	0.003633	3	0.00021	3	0.144	14	0.000767	3	0.0473	4	15.73333	3	0.261
5	12	0.0024	5	0.003767	7	0.00028	1	0.144667	3	0.00079	14	0.0474	4	15.77333	10	0.268667
6	5	0.002433	15	0.00388	4	0.0003	1	0.1448	4	0.00103	10	0.0478	4	15.81	4	0.275667
7	4	0.002567	5	0.0039	5	0.0004	1	0.146333	4	0.0021	4	0.48	10	15.82173	10	0.277
8	3	0.0027	5	0.0043	4	0.000567	1	0.146667			8	0.048433	3	15.86	4	0.28
9			5	0.004467			1	0.147333			10	0.049	4	15.88333	4	0.280667
10			9	0.0053			1	0.149167			4	0.049767	10	15.884	4	0.281
11							1	0.1495			4	0.050933	14	15.89667	14	0.282333
12							1	0.15			4	0.051833	4	15.90	10	0.282833
13							1	0.1527			3	0.052	4	15.94933	4	0.283667
14											5	0.0526	17	15.9751	4	0.284067
15											4	0.053633	10	16.03333	5	0.284367
16											5	0.0554			4	0.285233
17											5	0.056767			8	0.288333
18															3	0.29
19															5	0.3037
20															4	0.31
21															5	0.317
Average		0.00188		0.00385		0.000194		0.1462		0.000736		0.0499		15.84		0.2819
Std dev		0.00018		0.00019		0.000024		0.0031		0.000061		0.0015		0.20		0.0039
H		0.000374		0.000476		0.000219		0.002731		0.000287		0.001487		0.094815		0.004112
U ₁		0.00041		0.00051		0.00022		0.0041		0.00029		0.0021		0.22		0.0057
t-statistic		2.36		2.26		2.36		2.18		2.45		2.12		2.14		2.09
U ₂		0.00098		0.0012		0.00052		0.0090		0.00072		0.0045		0.47		0.012
U ₃		0.00035		0.00037		0.00018		0.0025		0.00027		0.0011		0.12		0.0026
Certified		0.0019		0.0038		0.0003		0.146		0.0007		0.050		15.8		0.282
Uncertainty		0.0005		0.0004		0.0001		0.002		0.0003		0.002		0.1		0.003
Tolerance		0.0010		0.0012		0.0002		0.009		0.0006		0.005		0.5		0.012

Unweighted mean and standard deviation were used to calculate Chromium. The weighted mean is 15.9479 and standard deviation is 0.0037. The weighted certified value is 15.95 with an uncertainty of 0.05 and tolerance of 0.20.

Analysis	*	Fe	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P
1	16	[79.91917]	4	0.565667	10	0.089233	2	0.045625	10	0.029167	4	2.01	2	0.005257	12	0.0185
2	10	80.04	10	0.568	4	0.0896	2	0.0470	4	0.030667	4	2.193333	2	0.005707	5	0.0199
3	4	80.06667	3	0.573	4	0.09	2	0.047533	4	0.030733	4	2.207333	2	0.005733	10	0.021367
4	4	80.07667	4	0.573333	3	0.0905	2	0.047933	3	0.032	3	2.21	2	0.005757	4	0.022233
5	16	[80.09]	4	0.576	10	0.0905	2	0.048067	4	0.032433	10	2.211	2	0.005967	3	0.0224
6	14	80.11333	4	0.576	14	0.090533	2	0.048633	4	0.033633	4	2.219333	2	0.006225	3	0.0225
7	16	[80.18]	4	0.5763	4	0.091267	2	0.048925	4	0.033967	10	2.243333	2	0.006333	14	0.0228
8	13	80.263	8	0.576333	4	0.091667	2	0.0500	4	0.0344	4	2.249333	2	0.0067	4	0.022867
9	3	80.27333	4	0.577	4	0.092367	2	0.050233	10	0.0346	3	2.253333	2	0.006733	4	0.0230
10	10	80.27333	14	0.579667	4	0.092633	2	0.050575	12	0.0350	4	2.253333	2	0.006867	10	0.023267
11	16	[80.29]	3	0.58	3	0.092967	2	0.0506	5	0.0353	4	2.253667	2	0.007663	4	0.023367
12	16	[80.33333]	4	0.58	10	0.093	2	0.051	3	0.0357	3	2.26			3	0.024
13			10	0.5806	10	0.093667			5	0.0382	10	2.26			10	0.024
14			10	0.583	7	0.093667			5	0.039567	14	2.263333			7	0.024533
15			3	0.586667	3	0.094			10	0.041	4	2.27			5	0.025567
16			4	0.5916	4	0.0943					10	2.292533			12	0.0264
17			4	0.5970	12	0.0950					4	2.3027			4	0.027667
18			10	0.643333	5	0.0989					8	2.314				
Average		80.170		0.5793		0.0921		0.0489		0.0342		2.2493		0.00593		0.02318
Std dev		0.043		0.0053		0.0023		0.0016		0.0015		0.0069		0.00022		0.00095
H		0.454649		0.006657		0.002083		0.001471		0.001223		0.018117		0.000559		0.00101
U ₁		0.46		0.0085		0.0031		0.0022		0.0019		0.019		0.00060		0.0014
t-statistic		2.20		2.11		2.11		2.20		2.14		2.11		2.23		2.12
U ₂		1.010		0.018		0.0065		0.0048		0.0041		0.041		0.0013		0.0029
U ₃		0.29		0.0042		0.0015		0.0014		0.0011		0.0096		0.00040		0.00071
Certified		80.2		0.579		0.092		0.049		0.034		2.25		0.0059		0.0232
Uncertainty		0.3		0.004		0.002		0.001		0.001		0.01		0.0004		0.0007
Tolerance		1.0		0.018		0.007		0.005		0.004		0.04		0.0013		0.0029

BS 431 * Code for method Certified values listed as weight percent

Analysis	*	S	*	Sb	*	Si	*	Sn	*	Ti	*	V	*	W
1	1	0.00354	5	0.0007	4	0.316	5	0.009067	5	0.00043	10	0.0496	14	0.008167
2	12	0.0044	5	0.0010	12	0.3650	4	0.011	3	0.0005	10	0.051667	12	0.0085
3	1	0.004667	5	0.0012	10	0.374467	5	0.012933	5	0.000597	4	0.053067	5	0.0106
4	1	0.004733	12	0.0012	4	0.3772	12	0.0130	12	0.00065	5	0.0590	4	0.0109
5	1	0.004833	5	0.0013	4	0.378	5	0.013167	5	0.0007	12	0.0590	5	0.011033
6	1	0.004933			5	0.381167	5	0.014133	4	0.001367	7	0.0596	5	0.011467
7	3	0.005			10	0.384	4	0.014533	4	0.0017833	4	0.059867	4	0.0116
8	1	0.005033			4	0.388	5	0.014633			3	0.0603	4	0.011767
9	10	0.0051			4	0.388333	5	0.014667			14	0.061233	10	0.0127
10	1	0.0052			6	0.388333					3	0.063	5	0.0130
11	1	0.005367			10	0.389333					4	0.063133	4	0.013333
12	1	0.005403			14	0.390667					4	0.063667	4	0.014333
13	1	0.005467			4	0.3947					4	0.063967	5	0.015833
14	1	0.005733			3	0.397333					4	0.065967		
15	1	0.006033			10	0.40					4	0.0664		
16					4	0.401333					10	0.066867		
17					3	0.41					5	0.0675		
18					3	0.415								
Average		0.00474		0.00107		0.3927		0.01344		0.00069		0.0619		0.01171
Std dev		0.00019		0.00011		0.0049		0.00069		0.00010		0.0017		0.00055
H		0.000513		0.000317		0.005111		0.000786		0.000283		0.001669		0.00074
U ₁		0.00055		0.00034		0.0071		0.0010		0.00030		0.0024		0.00092
t-statistic		2.14		2.78		2.11		2.31		2.45		2.12		2.18
U ₂		0.0015		0.00094		0.015		0.0024		0.00074		0.0051		0.0020
U ₃		0.00030		0.00042		0.0035		0.00080		0.00028		0.0012		0.00056
Certified		0.0047		0.0011		0.393		0.0134		0.0007		0.062		0.012
Uncertainty		0.0003		0.0004		0.008		0.0008		0.0003		0.002		0.001
Tolerance		0.0012		0.0009		0.015		0.0024		0.0006		0.005		0.002

BS 431 * Code for method Informational values listed as weight percent

Analysis	*	Mg	*	Zr
1	5	0.000193	3	0.0006
2	12	0.0002	5	0.00062
3	12	0.00025	12	0.0020
Average		0.00021		0.0011
Std dev		0.00019		0.0051
H		0.000221		0.000319
U ₁		0.00029		0.0051
t-statistic		4.30		4.30
U ₂		0.0012		0.022
U ₃		0.00072		0.030
(Informational)		(0.0002)		(0.001)

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. U₁ is the combined uncertainty from homogeneity and labs. U₂ is U₁ multiplied by the coverage factor (95 % t-statistic). U₃ is U₂ 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	* Pb	* Re	* Ta	* Zn			
1	12 0.012	12 0.032	5 22	5 4	12 0.19	12 0.17	12 0.11	12 0.35	12 0.42	12 3.7			
2			5 22	5 6				5 0.36		5 15			
3			5 23	5 8				5 0.36		5 15			
4			12 31	5 16				5 0.36		5 16			
5				5 17									
6				5 17									
7				12 36									

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 | 17 Wet |
| 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
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Dirats Laboratories	Westfield, MA	ACLASS	17025
NSL Analytical	Cleveland, OH	ACLASS	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Evans Analytical Group	Liverpool, NY	A2LA	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
Exova	Glendale Heights, IL	A2LA	17025

A2LA = American Association for Laboratory Accreditation
 ACLASS = 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; 501-320, 501-501, 501-502, 501-503, 501-504, 501-644, 501-676, 501-677, 501-911, 501-992, 501-993, 502-198, 502-257, 502-328, 502-348, 502-416, 502-494, 502-869; AR 148, 645, 654, 657, 659, 673, 688, 872, 960, 1647, 1652, 1656; BAS 69, 72, 464/1, 475; BS CSN 2-2, HON-T, SS4951, 30D, 56H, 185, 192A, 303, 316C, 316E, 410C, 1030, 2205, 4130; ECRM 85-1, 86-1, 87-1, 096-1, 532-1; IARM 12A, 23B, 41C, 42B; IMZ 1.85, 112, 156, 161, 171, 503; IPT 208Fe; NCS NS21006; SRM 16F, 55D, 101D, 101E, 133B, 155, 160B, 342, 343A, 345, 348, 361, 362, 363, 460, 1219, 1246, 1249, 1263A, 1264A, 1763A, 2159, 2166, 3101A, 3109A, 3155, 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, 502-257; BAS 475; BS HON-T, SS4951, 185, 192A, 303; ECRM 096-1, 532-1; NCS NS21006; SRM 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 431 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 Dunkirk Specialty Steel; Dunkirk, NY.

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 431-092315. You may obtain information 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

NIST Special Publication 829, Use of NIST Standard Reference Materials for Decisions on Performance of Analytical Chemical Methods and Laboratories

Certified by: _____ on September 23, 2015.

Beau R. Brammer