

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 8620C

Certified Reference Material for ASTM A331 Grade 8620 - UNS Number G86200

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
Al	0.0244	0.0008		Sn	0.0079	0.0005
As	0.0045	0.0005		Ti	0.0009	0.0002
C	0.205	0.003		V	0.0016	0.0003
Co	0.0059	0.0004				
Cr	0.551	0.005				
Cu	0.172	0.002				
Fe	[97.2]	0.5				
Mn	0.745	0.005				
Mo	0.193	0.003				
N	0.0068	0.0005				
Ni	0.591	0.005				
O	0.0012	0.0003				
P	0.0091	0.0004				
S	0.0250	0.0008				
Si	0.235	0.003				

Informational Values^{3,4}

B (0.0003)	Ca (0.0008)	Mg (0.0003)	Nb (0.001)	Pb (0.00004)
Sb (0.002)	W (0.0005)	Zr (0.0008)		

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, Ga, Ge, 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	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn
1	4	0.0202	5	0.003633	1	0.1992	5	0.0048	5	0.535567	3	0.163	10	97.16	4	0.720
2	5	0.0216	5	0.004167	1	0.204	12	0.0051	4	0.540	10	0.165	3	97.16333	4	0.736
3	10	0.023	3	0.00445	1	0.204333	3	0.0054	4	0.54433	4	0.167333	16	[97.17857]	4	0.740
4	12	0.0230	15	0.00449	1	0.204867	3	0.0057	10	0.547	5	0.168233	16	[97.18]	10	0.740667
5	3	0.02335	12	0.0045	3	0.20575	8	0.00582	4	0.549	4	0.168667	16	[97.21333]	3	0.747
6	3	0.024	4	0.0047	1	0.207277	3	0.00585	4	0.550667	4	0.16867	4	97.21333	14	0.748
7	4	0.024333	5	0.005167	1	0.207933	4	0.00587	10	0.551	14	0.171333	14	97.21667	4	0.7485
8	3	0.024733			1	0.209667	5	0.0059	3	0.551	3	0.17175	16	[97.2175]	10	0.752
9	4	0.025			1	0.210	4	0.006033	4	0.552667	3	0.172	10	97.250	4	0.7530
10	5	0.025033			1	0.210667	10	0.006133	4	0.557027	4	0.173667			3	0.753333
11	5	0.025267			1	0.210667	10	0.0065	3	0.558	10	0.176667			8	0.753333
12	3	0.025333			3	0.213	5	0.006567	3	0.56	4	0.1795			4	0.754
13	4	0.026133							4	0.560333	10	0.18			4	0.754333
14	14	0.026467							10	0.583667	8	0.180667			3	0.758
15	4	0.026533							3	0.587333	3	0.182			10	0.765
16									4	0.183					3	0.776333
17									12	0.1850						
Average		0.02438		0.00454		0.2050		0.00585		0.5515		0.1725		97.191		0.7448
Std dev		0.00089		0.00026		0.0038		0.00028		0.0053		0.0035		0.038		0.0057
H		0.0010		0.00051		0.0033		0.00056		0.0064		0.0030		0.60		0.0079
U ₁		0.0014		0.00057		0.0051		0.00063		0.0083		0.0046		0.60		0.0098
t-statistic		2.14		2.45		2.20		2.20		2.14		2.12		2.31		2.13
U ₂		0.0029		0.0014		0.011		0.0014		0.018		0.010		1.39		0.021
U ₃		0.00076		0.00053		0.0032		0.00040		0.0046		0.0024		0.46		0.0052
Certified		0.0244		0.0045		0.205		0.0059		0.551		0.172		[97.2]		0.745
Uncertainty		0.0008		0.0005		0.003		0.0004		0.005		0.002		0.5		0.005
Tolerance		0.0029		0.0014		0.011		0.0014		0.018		0.010		1.4		0.021

Analysis	*	Mo	*	N	*	Ni	*	O	*	P	*	S	*	Si	*	Sn
1	10	0.179	2	0.006333	12	0.5500	2	0.000922	5	0.007767	3	0.023525	10	0.217667	5	0.006833
2	4	0.181	2	0.00655	4	0.556	2	0.00115	7	0.008093	1	0.023733	3	0.225667	5	0.007067
3	3	0.188	2	0.0066	3	0.573667	2	0.001167	3	0.0086	1	0.023734	3	0.230	5	0.007767
4	4	0.190	2	0.00663	4	0.579	2	0.001267	10	0.0089	3	0.024	4	0.230	10	0.0078
5	4	0.191333	2	0.0068	10	0.580	2	0.001733	3	0.009	10	0.024	6	0.230667	12	0.0078
6	4	0.192567	2	0.006933	3	0.586	2	0.001843	4	0.009167	1	0.0243	3	0.23125	3	0.00785
7	3	0.194	2	0.006983	4	0.588667	2	0.001967	4	0.0093	1	0.024867	10	0.232	5	0.007877
8	7	0.194333	2	0.007057	3	0.593333	2	0.002125	4	0.00930	1	0.025333	10	0.232667	4	0.007967
9	3	0.195667	2	0.007163	3	0.59625			4	0.0094	1	0.025533	3	0.233	4	0.008067
10	4	0.1959			8	0.596667			10	0.009433	1	0.025667	14	0.233667	4	0.008133
11	3	0.196			4	0.596967			12	0.0095	1	0.025767	5	0.234133	9	0.0087
12	10	0.196			4	0.5988			3	0.009667	1	0.026267	4	0.234333		
13	4	0.197			14	0.602333			4	0.009767	1	0.026947	4	0.2350		
14	14	0.200			4	0.604667			14	0.010133			4	0.235667		
15	5	0.207133			10	0.607667			4	0.010367			5	0.237667		
16	12	0.2100			10	0.617			3	0.011167			4	0.242033		
17													4	0.244667		
18													12	0.2450		
Average		0.1933		0.00682		0.5913		0.00123		0.00905		0.02500		0.2347		0.00789
Std dev		0.0037		0.00026		0.0052		0.00015		0.00037		0.00091		0.0041		0.00029
H		0.0032		0.00059		0.0067		0.00034		0.00066		0.0010		0.0036		0.00063
U ₁		0.0049		0.00065		0.0085		0.00037		0.00076		0.0014		0.0055		0.00069
t-statistic		2.13		2.31		2.13		2.36		2.13		2.18		2.11		2.23
U ₂		0.011		0.0015		0.018		0.00088		0.0016		0.0030		0.012		0.0015
U ₃		0.0026		0.00050		0.0045		0.00031		0.00041		0.00084		0.0027		0.00047
Certified		0.193		0.0068		0.591		0.0012		0.0091		0.0250		0.235		0.0079
Uncertainty		0.003		0.0005		0.005		0.0003		0.0004		0.0008		0.003		0.0005
Tolerance		0.011		0.0015		0.018		0.0009		0.0016		0.0030		0.012		0.0015

BS 8620C * Code for method Certified values listed as weight percent

Analysis	*	Ti	*	V
1	3	0.00065	4	0.001043
2	4	0.000897	5	0.001233
3	5	0.000967	4	0.0013
4	12	0.0010	14	0.001333
5	5	0.001013	5	0.001467
6	4	0.001133	12	0.0016
7	4	0.0012	4	0.001767
8	3	0.0014	3	0.00195
9	14	0.0014	10	0.0021
10	10	0.0017	4	0.0028
Average		0.000948		0.00161
Std dev		0.000070		0.00012
H		0.00032		0.00037
U ₁		0.00032		0.00038
t-statistic		2.26		2.26
U ₂		0.00073		0.00087
U ₃		0.00023		0.00028
Certified		0.0009		0.0016
Uncertainty		0.0002		0.0003
Tolerance		0.0007		0.0009

BS 8620C * Code for method Informational values listed as weight percent

Analysis	*	B	*	Ca	*	Mg	*	Nb	*	Pb	*	Sb	*	W	*	Zr
1	7	0.00018	4	0.000433	5	0.0000967	5	0.00015	5	0.00003	4	0.0015	5	0.000243	12	0.00021
2	4	0.0002	3	0.000655	3	0.000213	5	0.0002	12	0.000038	12	0.0018	12	0.00050	3	0.0008
3	3	0.000388	4	0.000767	12	0.00023	5	0.00027	5	0.000039	4	0.0021	4	0.000733	3	0.0009
4	4	0.0005	4	0.000897	4	0.000453	12	0.00030	5	0.0000583					10	0.0013
5			12	0.0013	4	0.000467	3	0.00195								
6							10	0.0021								
7							4	0.002433								
8							4	0.0025								
9							4	0.0027								
Average		0.00032		0.0008		0.00029		0.0014		0.0000414		0.002		0.0005		0.0008
Std dev		0.00036		0.0022		0.00027		0.0046		0.0000023		0.012		0.0011		0.0024
H		0.00025		0.0003		0.00025		0.0004		0.00021		0.000		0.0003		0.0003
U ₁		0.00044		0.0022		0.00036		0.0046		0.00021		0.012		0.0011		0.0025
t-statistic		3.18		2.78		2.78		2.31		3.18		4.30		4.30		3.18
U ₂		0.0014		0.0062		0.0010		0.011		0.00065		0.053		0.0047		0.0078
U ₃		0.00070		0.0028		0.00045		0.0035		0.00033		0.030		0.0027		0.0039
(Informational)		(0.0003)		(0.0008)		(0.0003)		(0.001)		(0.00004)		(0.002)		(0.0005)		(0.0008)

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.

BS 8620C * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis *	Bi	* Ga	* Ge	* Zn
1	12 0.014	12 7.5	12 50	5 8.9
2		5 8.9		5 9.0
3		5 8.9		12 9.0
4		5 9.0		5 9.1

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
NSL Analytical	Cleveland, OH	ACCLASS	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	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
Dirats Laboratories	Westfield, MA	ACCLASS	17025
Exova	Glendale Heights, IL	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Northern Analytical Laboratory, Inc.	Londonderry, NH	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

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, 13X43100, 13XNSA11, 215XHC3, 215HC5; 501-102, 501-320, 501-501, 501-503, 501-504, 501-550, 501-644, 501-646, 501-676, 501-677, 501-991, 501-993, 502-257, 502-416; AR 642, 644, 646, 657, 660, 869, 872, 875, 1656, 8620; BAS 4-88, 55, 65, 409, 434/2, 464/1; BS 61C, 61D, 67C, 303, 1931, 3951, 4130, 4829A, 8620B, CSN 2-2; CKD 166A, 181; ECRM 85, 86, 87; IARM 30I, 35H; IMZ 112, 124, 504; IPT 208; JK 37; JSS 655-13; NCS NS11028; SRM 9D, 10G, 33D, 33E, 75G, 139B, 160B, 293, 361, 362, 363, 1162, 1170B, 1225, 1246, 1249, 1261, 1263A, 1264A, 1413, 1763, 1763A, 3109A, 3128, 3131A, 3137.

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, 501-991, 502-416; AR 8620; BAS 4-88; BS 61C, 61D, 67C, 1931, 8620B; NCS NS 11028; SRM 75G, 293, 362; SUS Fe 2/1.

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 8620C 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 Nucor Cold Finish, Oak Creek, WI.

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

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as used for production specimens. Avoid overheating the sample during surface preparation.

Certificate Number: The unique identification number for this certificate of analysis is 8620C-021315. You may obtain information on revisions of certificates from the internet at 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. 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 February 13, 2015.

Beau R. Brammer