Brammer Standard Company, Inc.

Certificate of Analysis
BS 8620F

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

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]			Certified Value[1]	Estimate of Uncertainty[2]
Al	0.040	0.001		Nb	0.0025	0.0005
As	0.0078	0.0006		Ni	0.427	0.009
C	0.212	0.003		O	0.0026	0.0004
Ca	0.0020	0.0005		P	0.0090	0.0007
Co	0.0089	0.0006		S	0.033	0.001
Cr	0.547	0.007		Si	0.243	0.003
Cu	0.234	0.006		Sn	0.0102	0.0009
Fe	97.1	0.2		Ti	0.0016	0.0004
Mn	0.85	0.02		V	0.0054	0.0006
Mo	0.206	0.006		W	0.0016	0.0004
N	0.0106	0.0008				

Informational Values[3,4]

B (0.0003)   Mg (0.0002)   Pb (0.002)   Sb (0.002)   Zr (0.0008)

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 **3** 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 **3** 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 Ag, Ce, Cl, F, Ga, Ge, In, La, Re, Sr, and Zn are shown on page 4.

The requirements of ISO Guides 30, 31, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis.

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

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo
1	10	0.038	5	0.0063	10	0.205	12	0.00055	10	0.007	4	0.5362	10	0.2266667	10	97.08333	8	0.8186667	4	0.1993667
2	4	0.0387333	3	0.007	1	0.2063	4	0.0017	5	0.00792333	17	0.5397333	10	0.2281667	3	97.09	4	0.833	3	0.20
3	4	0.039	4	0.00736667	1	0.21	4	0.0018	5	0.00826667	4	0.54	4	0.2293333	16	[97.14]	4	0.8397333	4	0.20
4	4	0.0392	3	0.0074	1	0.2113333	4	0.00186333	5	0.0085	4	0.5413333	4	0.2296333	4	97.15	4	0.8414	4	0.2018667
5	3	0.0392	5	0.0074	3	0.212	3	0.00199	10	0.00886667	4	0.5432333	8	0.2296667	16	[97.15]	4	0.8483667	4	0.2033667
6	4	0.0395667	15	0.00781333	3	0.213	4	0.00296667	8	0.00897667	10	0.544	4	0.2298333	16	[97.1684]	4	0.8486667	10	0.2036333
7	5	0.0397333	10	0.00796667	1	0.2136667			4	0.00906667	4	0.5443333	4	0.23	16	[97.18334]	3	0.85	4	0.2036667
8	4	0.0401667	10	0.0081	4	0.214			10	0.0092	10	0.5454333	10	0.232	13	97.24767	3	0.85	4	0.2036667
9	3	0.0405	4	0.00833333	1	0.2143333			4	0.00926667	3	0.547	4	0.2326667			4	0.8503333	4	0.2063333
10	3	0.041	5	0.0084	3	0.215			5	0.0093	3	0.547	4	0.2329667			10	0.8506333	10	0.207
11	10	0.0412	12	0.0091	4	0.2163333			3	0.0093	4	0.5493333	4	0.233			3	0.851	7	0.2073333
12	4	0.0412			1	0.2174333			3	0.0095	3	0.551	4	0.2333333			4	0.8526667	3	0.2073333
13	3	0.042			1	0.22			3	0.01	4	0.565	3	0.235			10	0.858	10	0.209
14	4	0.0421333									10	0.5786667	3	0.238			4	0.86	10	0.21
15													3	0.243			10	0.87	3	0.21
16													10	0.244			10	0.8816667	3	0.210
17																	4	0.882	5	0.211
18																			4	0.214
Average		0.0404		0.00785		0.2116		0.00203		0.00893		0.5470		0.2343		97.133		0.8509		0.2059
Std Dev		0.0013		0.00033		0.0036		0.00011		0.00046		0.0044		0.0032		0.040		0.0047		0.0029
H		0.0018		0.00084		0.0042		0.00049		0.00088		0.0072		0.0044		0.27		0.009		0.0041
U_1		0.0022		0.00090		0.0055		0.00051		0.0010		0.0084		0.0054		0.27		0.010		0.0050
t-statistic		2.16		2.23		2.18		2.57		2.18		2.16		2.13		2.36		2.12		2.11
U_2		0.0048		0.0020		0.012		0.0013		0.0022		0.018		0.012		0.65		0.022		0.011
U_3		0.0013		0.00060		0.0033		0.00053		0.00060		0.0049		0.0029		0.23		0.0054		0.0025
Certified		**0.040**		**0.0078**		**0.212**		**0.0020**		**0.0089**		**0.547**		**0.234**		**97.1**		**0.85**		**0.206**
Uncertainty		0.001		0.0006		0.003		0.0005		0.0006		0.007		0.006		0.2		0.02		0.006
Tolerance		0.005		0.0020		0.012		0.0013		0.0022		0.021		0.018		0.6		0.06		0.018

Analysis	*	N	*	Nb	*	Ni	*	O	*	P	*	S	*	Si	*	Sn	*	Ti	*	V
1	2	0.010	10	0.001	5	0.393	2	0.002	4	0.007	10	0.01	6	0.2396667	10	0.008	12	0.0003367	10	0.003
2	2	0.01000	4	0.00176667	4	0.405	2	0.00226667	5	0.00803333	1	0.029	4	0.240	10	0.0091	4	0.0013667	4	0.0045567
3	2	0.0104	4	0.002	4	0.4186	2	0.00233333	3	0.0083	1	0.0316333	4	0.2412	3	0.00923	5	0.0014	4	0.0048267
4	2	0.0104733	4	0.0021	10	0.4196667	2	0.00234567	4	0.00843333	3	0.032	10	0.2416667	5	0.00927	5	0.0014667	5	0.0048667
5	2	0.0105667	10	0.0026	4	0.42	2	0.00243667	7	0.00843667	3	0.032	3	0.242	4	0.00953	5	0.0015033	5	0.0050333
6	2	0.0105667	4	0.00266667	3	0.423	2	0.0025	5	0.00856667	1	0.0320667	3	0.242	5	0.00961	4	0.0016	3	0.0054
7	2	0.0106667	3	0.003	4	0.4253333	2	0.00264333	3	0.009	3	0.0325	10	0.243	4	0.00977	3	0.0018	4	0.0056667
8	2	0.0107667	3	0.0031	10	0.4293333	2	0.00306667	3	0.009	1	0.0328	3	0.243	5	0.00987	10	0.0018333	3	0.0056667
9	2	0.0112667			8	0.4293333	2	0.0034	10	0.009	4	0.0329333	3	0.2433333	3	0.01	4	0.0018333	4	0.0057
10	2	0.012			4	0.4298667	2	0.00348333	10	0.00916667	10	0.033	10	0.2443	3	0.01	10	0.0019	10	0.0057
11					4	0.4299333			12	0.00916667	1	0.0330333	4	0.2458667	5	0.01023	4	0.002	4	0.0057333
12					3	0.43			10	0.0094	1	0.0339	10	0.246	10	0.0106	3	0.002	3	0.0058
13					4	0.4313333			4	0.00946667	1	0.0343333	4	0.2463333	10	0.0107	3	0.0021	10	0.0058667
14					3	0.433			4	0.0096	1	0.0355	4	0.2506667	3	0.011	4	0.0021333	3	0.006
15					10	0.434			4	0.00973333	4	0.036	5	0.2506667	4	0.01117			10	0.0061333
16					3	0.439			7	0.01	12	0.0390			4	0.0118			4	0.008
17					4	0.441			10	0.0104	1	0.053			4	0.012				
18					10	0.459			3	0.0109										
Average		0.01060		0.00252		0.427244		0.00257		0.00897		0.0331		0.2433		0.01018		0.001592		0.00537
Std Dev		0.00050		0.00011		0.000075		0.00020		0.00041		0.0012		0.0039		0.00039		0.000052		0.00027
H		0.0010		0.00053		0.0062		0.00054		0.00089		0.0016		0.0045		0.0009		0.0004519		0.00072
U_1		0.0011		0.00055		0.0062		0.00057		0.00097		0.0020		0.0060		0.0010		0.00045		0.00077
t-statistic		2.26		2.36		2.11		2.26		2.11		2.12		2.14		2.12		2.16		2.13
U_2		0.0024		0.0013		0.013		0.0013		0.0021		0.0043		0.013		0.0021		0.00098		0.0016
U_3		0.00077		0.00046		0.0031		0.00041		0.00048		0.0010		0.0033		0.00052		0.00026		0.00041
Certified		**0.0106**		**0.0025**		**0.427**		**0.0026**		**0.0090**		**0.033**		**0.243**		**0.0102**		**0.0016**		**0.0054**
Uncertainty		0.0008		0.0005		0.009		0.0004		0.0007		0.001		0.003		0.0009		0.0004		0.0006
Tolerance		0.0024		0.0013		0.027		0.0013		0.0021		0.004		0.013		0.0027		0.0012		0.0018

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

Analysis	*	W
1	12	0.0008933
2	3	0.0012
3	10	0.0014
4	5	0.0018933
5	4	0.0019667
6	10	0.002
7	5	0.0020667
8	5	0.0021
Average		0.001614
Std Dev		0.000068
H		0.00045
U₁		0.00046
t-statistic		2.36
U₂		0.0011
U₃		0.00038
Certified		**0.0016**
Uncertainty		0.0004
Tolerance		0.0011

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

Analysis	*	B	*	Mg	*	Pb	*	Sb	*	Zr
1	5	0.0001	3	0.00008	12	0.000096	4	0.0018	12	0.000025
2	7	0.0001867	12	0.000090	5	0.0002167	12	0.0020	5	0.0000333
3	4	0.0003333	5	0.0001	5	0.00028			5	0.0001
4	12	0.0003667	4	0.00035667	3	0.0003			3	0.0002
5	3	0.0004			5	0.0003			5	0.00045333
6	3	0.00043			5	0.0003			4	0.0039
7					10	0.0004				
8					10	0.003				
9					4	0.0041				
10					4	0.007				
Average		0.00030		0.000157		0.0016		0.002		0.0008
Std Dev		0.00029		0.000081		0.0053		0.016		0.0019
H		0.00027		0.00022		0.0005		0.000		0.0004
U₁		0.00039		0.00024		0.0053		0.016		0.0020
t-statistic		2.57		3.18		2.26		12.71		2.57
U₂		0.0010		0.00075		0.012		0.20		0.0050
U₃		0.00041		0.00038		0.0038		0.140		0.0021
informational		(0.0003)		(0.0002)		(0.002)		(0.002)		(0.0008)

For each element, in accordance with the requirements of ISO 17034 and Guide 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 it's 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:

$$C_L = \sqrt{S_L^2 + U_L^2} \qquad W_L = \frac{1}{C_L^2} \qquad A = \frac{\sum_{i=1}^{n} W_L M_L}{\sum_{i=1}^{n} W_L} \qquad S = \frac{1}{\sqrt{\sum_{i=1}^{n} W_L}} \qquad U_1 = \sqrt{H^2 + S^2} \qquad U_2 = t \times U_1 \qquad U_3 = \frac{U_2}{\sqrt{n}}$$

*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 Uncertainty is a measure of the quality of the **Certified** value.*

The Tolerance is a measure of the expected performance of an analysis. This involves further expanding the sample uncertainty to include instrument and operator uncertainty, for those without access to such calculations.

For further information regarding the confidence interval for the certified value see ISO Guide 35:2006 section 6.

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

Analysis	*	Ag	*	Ce	*	Cl	*	F	*	Ga	*	Ge	*	In	*	La	*	Re	*	Sr
1	12	0.77	12	0.006	12	0.04	12	0.05	12	8.3	12	11	12	0.13	12	0.005	12	0.03	12	0.01
2	12	0.78	12	0.007	12	0.05	12	0.06	12	8.5	12	11	12	0.16			12	0.03	12	0.01
3	12	0.8			12	0.07			12	8.8	12	11	12	0.2						

Analysis	*	Zn
1	12	9.1
2	12	9.1
3	12	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	17	AAS
6	Gravimetric	12	GD Mass Spectrometry		

ICP = Inductively Coupled Plasma   GF = Graphite Furnace   GD = Glow Discharge
DCP = Direct Current Plasma   HG = Hydride Generation AAS = Atomic Absorption Spectrometry

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
LECO Corporation	St. Joseph, MI	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Exova	Santa Fe Spring, CA	A2LA	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025

A2LA = American Association for Laboratory Accreditation
ANAB = ANSI-ASQ National Accreditation Board
CNAS = China National Accreditation Service
PCA = Polish Center For Accreditation

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: 13X349D, 12XLA2; AR 612B, 645, 654, 657, 875, 882, 1648, 1650,1652, 1653; BAS 4-94, 206/3, 342, 406, 408, 434, 451, 458/1, 459, 460, 464/1; BS D-6, 56D, 56H, 61C, 61G, 68E, 300, 1026, 2931A, 2941, 2992, 8620B, 8620E; ECRM 85-1, 86-2, 87-1; IARM 14D, 19F, 28H, 28I, 32B, 32C, 32D, 73A, 182B, 210C; IMZ 74A, 112, 114, 124, 132; LECO 501-320, 501-501, 501-503, 501-504, 501-505, 501-644, 501-646, 502-675, 501-676, 501-677, 501-991, 501-993, 502-197, 502-348, 502-885, 502-856, 502-870, 502-873, 502-874, 502-894, 502-895, 502-916, 502-918, 504-646; SRM 72F, 132A, 153A, 160B, 291, 361, 362, 363, 364, 1162, 1262A, 1264A, 1265A, 1762; Y41340b.

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 — BAS 4-94, 458/1; BS 56D, 56H, 2941, 2992, 8620B, 8620E; ECRM 086-1; LECO 501-676, 502-873; SRM 291, 1262A; Y41340b.

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 8620F is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Storage: This CRM must be stored in a cool, dry, non-corrosive environment.

Source: The bar stock for this CRM was produced by Hamilton Specialty Bar; Hamilton, Ontario

Form: This CRM is machined in the form of a disc, approximately 38mm 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.

> Caution: CRM contains significant insoluble soft metal inclusions. Surface smearing may occur. Spark atomic emission spectrometers may require extended preburns to compensate.

Certificate Number: The unique identification number for this certificate of analysis is 8620F-072518. 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 Standard 17034 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 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 9001:2015   Quality Management Systems - Requirements

ISO Guide 30:2015   Terms and definitions used in connection with reference materials + 2008 amendment

ISO Guide 31:2015   Reference materials - Contents of certificates and labels

ISO Guide 33:2015   Uses of certified reference materials

ISO Standard 17034:2016 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, 100 Barr Harbor Dr., West Conshohocken, PA 19428.

*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 July 25, 2018.

Beau R. Brammer

President