Brammer Standard Company, Inc.

Certificate of Analysis

BS 8620E

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	**0.027**	0.001	**Ni**	**0.564**	0.008
As	**0.0044**	0.0006	**O**	**0.0016**	0.0004
C	**0.210**	0.003	**P**	**0.011**	0.001
Ca	**0.0010**	0.0003	**S**	**0.0238**	0.0009
Co	**0.0068**	0.0004	**Sb**	**0.0015**	0.0003
Cr	**0.541**	0.009	**Si**	**0.255**	0.006
Cu	**0.186**	0.006	**Sn**	**0.011**	0.001
Fe	**97.2**	0.2	**Ti**	**0.0016**	0.0004
Mn	**0.800**	0.008	**V**	**0.0024**	0.0007
Mo	**0.223**	0.004	**W**	**0.0008**	0.0003
N	**0.0080**	0.0005			

Informational Values[3,4]

B (0.0003) Mg (0.0003) Nb (0.002) Pb (0.0008) Ta (0.0004)
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 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, Na, and Re 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 8620E * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo
1	4	0.01803	4	0.0037	1	0.194233333	12	0.00073	4	0.00517	18	0.51	10	0.15	13	97.0147	10	0.7573	18	0.21333
2	10	0.0243	5	0.00397	1	0.203	3	0.00087	5	0.00573	4	0.527	3	0.17733	4	97.0633	4	0.77033	4	0.215
3	10	0.026	5	0.00427	10	0.204666667	4	0.00091	10	0.006	4	0.528333333	4	0.17933	10	97.0667	4	0.77367	4	0.21533
4	3	0.0261	5	0.00427	1	0.206	4	0.00093	8	0.00633	4	0.529	4	0.17967	3	97.0767	4	0.77367	4	0.21533
5	4	0.02617	4	0.00433	3	0.208	4	0.00093	10	0.00633	10	0.53	3	0.18	16	[97.0793]	4	0.792	4	0.216
6	3	0.0266	4	0.0045	3	0.209	4	0.00107	4	0.00645	4	0.537666667	4	0.18	16	[97.096]	14	0.79267	14	0.21933
7	14	0.02667	10	0.0048	1	0.21	4	0.0011	4	0.00663	14	0.539666667	10	0.18133	16	[97.0988]	3	0.797	3	0.22
8	4	0.02747	3	0.0048	3	0.21	14	0.0011	4	0.00667	10	0.54	4	0.18167	14	97.1	3	0.8	4	0.22
9	4	0.02763	3	0.0049	1	0.2109	4	0.00113	4	0.0067	3	0.54	3	0.183	16	[97.102]	4	0.80137	7	0.22067
10	4	0.0277	10	0.005	1	0.211333333	4	0.0015	12	0.00673	13	0.540666667	10	0.18367	18	97.1267	3	0.802	10	0.221
11	3	0.028	12	0.00517	1	0.211666667			3	0.0069	10	0.542666667	4	0.186	16	[97.13]	8	0.803	5	0.22107
12	4	0.02807	10	0.00533	1	0.212666667			5	0.007	4	0.5427	4	0.18767	10	97.21	4	0.80333	4	0.22263
13	4	0.0286	5	0.00567	1	0.2144			3	0.007	3	0.544	10	0.188	4	97.4	4	0.80333	4	0.22267
14	3	0.029	14	0.00713	1	0.218466667			3	0.007	4	0.5463	10	0.19	4	97.4	4	0.80383	4	0.22287
15	4	0.02967			1	0.232			14	0.00987	4	0.546666667	3	0.19	4	97.5	4	0.80433	10	0.223
16	10	0.03							4	0.01	13	0.546666667	4	0.19	10	97.6397	10	0.806	3	0.223
17	5	0.03077							10	0.012	4	0.5467	8	0.19	10	97.668	4	0.8087	3	0.226
18	12	0.034									4	0.55	4	0.19087			10	0.81	10	0.226
19											3	0.551	14	0.19233			18	0.81333	4	0.226
20											4	0.551667	4	0.19267			4	0.821	4	0.22667
21											4	0.559	4	0.19287			4	0.822	3	0.227
22											3	0.578667	4	0.19433			10	0.827	4	0.2277
23											10	0.580	18	0.20			3	0.83467	10	0.23
24											10	0.59	5	0.21417			10	0.85	10	0.23033
Average		0.02683		0.00443		0.2102		0.001004		0.00679		0.5414		0.1855		97.194		0.8005		0.2226
Std Dev		0.00092		0.00020		0.0031		0.000054		0.00017		0.0038		0.0028		0.021		0.0046		0.0031
H		0.0012		0.00057		0.0038		0.00035		0.00068		0.0068		0.0035		0.45		0.0089		0.0039
U1		0.0015		0.00061		0.0049		0.00035		0.00070		0.0078		0.0045		0.45		0.010		0.0050
t-statistic		2.11		2.16		2.14		2.26		2.12		2.07		2.07		2.12		2.07		2.07
U2		0.0033		0.0013		0.010		0.00080		0.0015		0.016		0.0093		0.95		0.021		0.010
U3		0.00077		0.00035		0.0027		0.00025		0.00036		0.0033		0.0019		0.23		0.0042		0.0021
Certified		**0.027**		**0.0044**		**0.210**		**0.0010**		**0.0068**		**0.541**		**0.186**		**97.2**		**0.800**		**0.223**
Uncertainty		0.001		0.0006		0.003		0.0003		0.0004		0.009		0.006		0.2		0.008		0.004
Tolerance		0.003		0.0018		0.010		0.0008		0.0015		0.027		0.018		1.0		0.024		0.016

Analysis	*	N	*	Ni	*	O	*	P	*	S	*	Sb	*	Si	*	Sn	*	Ti	*	V
1	2	0.0075	4	0.546	2	0.000997333	4	0.009	10	0.0164	4	0.001	10	0.24	12	0.00787	3	0.001	12	0.0016
2	1	0.0076	4	0.546	2	0.001053333	4	0.00933	1	0.02	4	0.001133333	3	0.245	5	0.0088	4	0.001	5	0.00173
3	2	0.008	4	0.54733	3	0.00125	7	0.01027	3	0.022	5	0.001166667	4	0.2477	5	0.00973	12	0.00101	5	0.00176
4	2	0.008	8	0.55033	2	0.001436667	14	0.01037	4	0.02233	4	0.0014	7	0.24867	3	0.01	5	0.00127	4	0.0018
5	2	0.00801	4	0.55067	2	0.0017	4	0.0104	4	0.02253	10	0.0015	3	0.249	10	0.01	10	0.00133	4	0.00187
6	2	0.00809	3	0.55233	2	0.0017	4	0.01043	10	0.023	5	0.0017	4	0.24933	4	0.01027	4	0.0014	5	0.00197
7	2	0.0081	4	0.55633	2	0.002	10	0.01067	3	0.023	5	0.001733333	18	0.25	4	0.01063	10	0.0014	10	0.002
8	2	0.00823	3	0.557	2	0.00257	4	0.0107	1	0.02303	12	0.0018	10	0.25	5	0.0107	5	0.0014	3	0.002
9	2	0.00829	4	0.558	2	0.0026	7	0.011	1	0.02306	5	0.001822	3	0.25	5	0.01083	4	0.00141	4	0.00207
10	2	0.0085	10	0.56			5	0.01127	1	0.0231			14	0.25033	4	0.01083	5	0.00152	3	0.0021
11	3	0.0086	10	0.561			4	0.01167	1	0.02367			10	0.251	10	0.011	3	0.0019	4	0.0023
12	2	0.01213	10	0.56267			4	0.0117	3	0.0238			4	0.25167	4	0.0111	10	0.002	10	0.003
13			4	0.5664			3	0.012	10	0.024			4	0.252	10	0.01133	4	0.002	3	0.003
14			6	0.56667			10	0.012	1	0.0244			4	0.25383	14	0.01193	4	0.00207	4	0.003
15			14	0.567			3	0.012	1	0.0246			6	0.25667	4	0.012	14	0.00213	10	0.003
16			4	0.568			3	0.01273	1	0.0261			10	0.257	3	0.013	3	0.00218	14	0.00317
17			4	0.5697			10	0.01273	1	0.02677			4	0.26	3	0.0143	4	0.0022	5	0.00413
18			3	0.57			3	0.0128	1	0.02723			4	0.2633						
19			3	0.571			10	0.013	12	0.034			3	0.265						
20			4	0.5716			12	0.01467					4	0.268						
21			4	0.57667			10	0.0158					4	0.27067						
22			10	0.58																
23			18	0.59333																
24			10	0.6048																
Average		0.00804		0.564		0.00156		0.01095		0.02379		0.00147		0.2548		0.01118		0.001602		0.002382
Std Dev		0.00030		0.012		0.00012		0.00039		0.00081		0.00011		0.0036		0.00035		0.000077		0.000077
H		0.00072		0.007		0.00040		0.00082		0.0012		0.00039		0.0042		0.00083		0.00040		0.00046
U1		0.00078		0.013		0.00042		0.00091		0.0014		0.00041		0.0055		0.00090		0.00041		0.00047
t-statistic		2.20		2.07		2.31		2.09		2.10		2.31		2.09		2.12		2.12		2.12
U2		0.0017		0.028		0.0010		0.0019		0.0030		0.00094		0.012		0.0019		0.00087		0.0010
U3		0.00050		0.0057		0.00032		0.00042		0.00069		0.00031		0.0025		0.00046		0.00021		0.00024
Certified		**0.0080**		**0.564**		**0.0016**		**0.011**		**0.0238**		**0.0015**		**0.255**		**0.011**		**0.0016**		**0.0024**
Uncertainty		0.0005		0.008		0.0004		0.001		0.0009		0.0003		0.006		0.001		0.0004		0.0007
Tolerance		0.0017		0.024		0.0012		0.003		0.0024		0.0009		0.018		0.003		0.0012		0.0021

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

Analysis	*	W
1	4	0.00077
2	5	0.00077
3	5	0.0008
4	5	0.00083
5	12	0.00084
6	4	0.001
7	4	0.00117
Average		0.000842
Std Dev		0.000073
H		0.00033
U1		0.00034
t-statistic		2.45
U2		0.00083
U3		0.00032
Certified		**0.0008**
Uncertainty		0.0003
Tolerance		0.0008

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

Analysis	*	B	*	Mg	*	Nb	*	Pb	*	Ta	*	Zr
1	3	0.00008	5	0.0001	12	0.000073	12	0.000020	5	0.00016	5	0.00005
2	5	0.0001	12	0.00017	3	0.0001	5	0.00003	5	0.00033	5	0.00007
3	12	0.00017	5	0.0002	5	0.0001	5	0.00003	4	0.00033	12	0.000076
4	4	0.0002	4	0.0002	4	0.000266667	5	0.000038	12	0.00041	5	0.000093
5	3	0.00025	3	0.00029	5	0.000713333	3	0.0003	5	0.0006	4	0.0006
6	3	0.0003	4	0.00036	4	0.0012	10	0.001			10	0.0008
7	4	0.00117	3	0.00069	10	0.0016	4	0.001			3	0.0008
8					3	0.002	4	0.0037			10	0.001
9					4	0.002833333					5	0.0013
10					4	0.01					4	0.003
Average		0.00032		0.00029		0.0019		0.0008		0.00037		0.0008
Std Dev		0.00030		0.00024		0.0069		0.0016		0.00046		0.0015
H		0.00026		0.00026		0.0004		0.0003		0.00027		0.0003
U1		0.00040		0.00035		0.0069		0.0016		0.00054		0.0015
t-statistic		2.45		2.45		2.26		2.36		2.78		2.26
U2		0.0010		0.00085		0.016		0.0038		0.0015		0.0034
U3		0.00037		0.00032		0.0050		0.0014		0.00067		0.0011
Informationa		(0.0003)		(0.0003)		(0.002)		(0.0008)		(0.0004)		(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 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 8620E * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ag	*	Ce	*	Cl	*	F	*	Ga	*	Ge	*	In	*	Na	*	Re
1	12	0.38	12	0.03	12	0.02	12	0.01	12	8.1	12	69	12	0.32	12	0.05	12	0.15
2	12	0.39	12	0.03	12	0.03	12	0.02	12	8.1	12	70			12	0.05	12	0.17
3	12	0.43	12	0.03	12	0.03			12	8.3	12	71			12	0.05	12	0.27

Analytical Method Codes:

1 Combustion (ASTM E1019)
2 Fusion (ASTM E1019)
3 Spark Atomic Emission
4 ICP Atomic Emission
5 ICP Mass Spectrometry
6 Gravimetric
7 Photometric
8 Flame Atomic Absorption
9 GF Atomic Absorption
10 X-Ray Fluorescence
11 GD Atomic Emission
12 GD Mass Spectrometry
13 Titrimetric
14 DCP Atomic Emission
15 HG Atomic Fluorescence
16 Difference
17 Wet
18 PIXE

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

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
Exova	Glendale Heights, Il	A2LA	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
TUV Rheinland India Pvt Ltd	Bangalore, India	NABL	17025
Andrew S. McCreath & Son, Inc.	Harrisburg, PA	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025

A2LA = American Association for Laboratory Accreditation
ANAB = ANSI-ASQ National Accreditation Board
CNAS = China National Accreditation Service
NABL = National Accreditation Board for Testing and Calibration Laboratories
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 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: 12X10180, 12X12749, 12X12749W, 12X352D, 12X353E, 12XLA5, 24X7001, 28X6256, 28X7182; AR 642, 644, 654, 657, 668, 670, 673, 872, 875, 892, 1648, 1653, 8620; BAS 4/88, 342, 346A, 434, 434/2, 458, 459, 464/1; BS CSN 2-2, H3C, TM-1, 32, 56H, 61C, 61D, 61G, 200-1, 200A, 625C, 718D, 750C, 800, 1026, 1030, 1931, 1932, 8620B, 8620C; CKD 181A; ECRM 85-5, 86-1, 87-1; IARM 32B, 32C, 32D, 35H, 51C, 54A, 62C, 65B, 95B, 158B, 203A; IMN 90/1; IMZ 74, 112; JK 37; LECO 501-320, 501-501, 501-502, 501-503, 501-504, 501-550, 501-644, 501-674, 501-675, 501-675, 501-676, 501-993, 502-102, 502-873; NCS NS20035B; SRM C2400, 9D, 72F, 160B, 291, 293, 361, 362, 363, 364, 1112, 1155, 1155A, 1162, 1172, 1223, 1246, 1247, 1250, 1261, 1262, 1265A, 1269, 1652, 3109A, 3168A; Y 41340B.

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 — AR 8620; BAS 4/88, 458; BS 61C, 61D, 1931, 1932, 8620B; LECO 501-676, 502-873; NCS NS20035B; SRM 291, 293; 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 8620E 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 Nucor Corporation; Norfolk, NE.

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.

> 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 8620E-060917. 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.
14603 Benfer Road
Houston, Texas 77069-2895 USA
Phone: (281) 440-9396 Web: www.brammerstandard.com
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 9001:2008 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 30:2015 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 June 09, 2017.

Beau R. Brammer

President