Brammer Standard Company, Inc.

Certificate of Analysis

BS C-2000

Certified Reference Material for Hastelloy C-2000 - UNS Number N06200

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.29**	0.01	**Mn**	**0.19**	0.01
As	**0.0012**	0.0003	**Mo**	**15.5**	0.1
Co	**0.076**	0.005	**N**	**0.018**	0.001
Cr	**22.54**	0.09	**Ni**	**58.7**	0.2
Cu	**1.52**	0.03	**O**	**0.0011**	0.0003
Fe	**1.00**	0.05	**S**	**0.0008**	0.0003
Mg	**0.0075**	0.0009			

Reference Values[3,4]

	Reference Value[1]	Estimate of Uncertainty[2]		Reference Value[1]	Estimate of Uncertainty[2]
C	**<0.005**		**Ti**	**0.004**	0.002
Nb	**0.02**	0.01	**V**	**0.011**	0.003
P	**<0.01**		**W**	**0.15**	0.05
Si	**<0.03**				

Informational Values[3,5]

B (0.0009)	Ca (0.0009)	Pb (0.0003)	Sb (0.0006)	Sn (0.0005)
Ta (0.002)	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 3-4 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 3-4 for more information on its calculation.

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

[4] Reference values are not certified and are provided for information only.

[5] Values in parentheses are not certified and are provided for information only.

Trace element information values for Ga, Ge, In, Ir, Os, Pt, Re, U, 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 C-2000 * Code for method Certified values listed as weight percent

Analysis	*	**Al**	*	**As**	*	**Co**	*	**Cr**	*	**Cu**	*	**Fe**	*	**Mg**	*	**Mn**	*	**Mo**	*	**N**
1	**4**	0.2545	**5**	0.00081	**5**	0.06636667	**3**	22.2	**3**	1.45666667	**4**	0.92666667	**11**	0.006	**4**	0.171	**4**	15.4027333	**2**	0.01533
2	**3**	0.26666667	**15**	0.000937	**4**	0.0709	**3**	22.4733333	**4**	1.4745	**4**	0.933	**4**	0.00636	**8**	0.17266667	**4**	15.4333333	**2**	0.01667
3	**4**	0.26866667	**9**	0.001067	**12**	0.0730	**11**	22.49	**4**	1.503	**4**	0.937	**4**	0.00658	**4**	0.17333333	**11**	15.44	**2**	0.01793
4	**11**	0.282	**5**	0.00109	**4**	0.07316667	**4**	22.4953333	**10**	1.512	**10**	0.961	**12**	0.00696667	**4**	0.18125	**4**	15.4505333	**2**	0.01803
5	**4**	0.28333333	**4**	0.001167	**8**	0.0734	**4**	22.5086667	**4**	1.51266667	**4**	0.973	**5**	0.00713333	**4**	0.18133333	**4**	15.4566667	**2**	0.0186
6	**5**	0.28366667	**12**	0.0012	**3**	0.076	**10**	22.52	**4**	1.51313333	**4**	0.99106667	**4**	0.00723333	**10**	0.182	**10**	15.47	**2**	0.0187
7	**4**	0.287	**5**	0.001333	**3**	0.0766	**14**	22.5333333	**4**	1.51866667	**4**	1.00017	**3**	0.0073	**4**	0.18519333	**4**	15.4793333	**2**	0.01893
8	**10**	0.288	**3**	0.0014	**11**	0.0773	**4**	22.5335333	**4**	1.51933333	**4**	1.005	**4**	0.00743333	**4**	0.18646667	**4**	15.4925	**2**	0.01897
9	**14**	0.29033333	**9**	0.0014	**4**	0.07736667	**4**	22.57	**10**	1.534	**4**	1.00536667	**2**	0.008	**5**	0.188	**14**	15.6	**2**	0.0192
10	**4**	0.29083333	**11**	0.0015	**10**	0.079	**10**	22.59	**3**	1.54	**11**	1.01	**4**	0.00833333	**11**	0.196	**3**	15.6133333	**2**	0.01933
11	**4**	0.29083333			**4**	0.0792	**13**	22.6083333	**4**	1.54993333	**3**	1.01	**14**	0.00896667	**3**	0.20	**4**	15.6216667	**2**	0.0195
12	**4**	0.29205			**4**	0.0795	**4**	22.6166667	**14**	1.55	**14**	1.02	**4**	0.0091	**14**	0.20033333	**4**	15.6309667	**2**	0.02046
13	**4**	0.30016667			**14**	0.08016667	**4**	22.6256667	**4**	1.554	**10**	1.036			**10**	0.202	**10**	15.65		
14	**3**	0.31			**4**	0.08036667	**4**	22.7330	**11**	1.57	**4**	1.052			**4**	0.2029	**3**	15.74		
15					**4**	0.084					**3**	1.19			**3**	0.203				
16															**4**	0.2093				
Average		0.2899		0.00119		0.076422		22.535562		1.5223		1.0027		0.00746		0.189674		15.534362		0.01796
Std Dev		0.0043		0.00010		0.000082		0.000085		0.0073		0.0068		0.00030		0.000079		0.000085		0.00071
H		0.0055		0.00045		0.0028		0.071		0.014		0.011		0.00095		0.0044		0.056		0.0014
U_1		0.0070		0.00047		0.0028		0.071		0.016		0.013		0.0010		0.0044		0.056		0.0016
t-statistic		2.16		2.26		2.14		2.16		2.16		2.14		2.20		2.13		2.16		2.20
U_2		0.015		0.0011		0.0060		0.15		0.034		0.027		0.0022		0.0094		0.12		0.0035
U_3		0.0040		0.00033		0.0015		0.041		0.0090		0.0071		0.00063		0.0023		0.032		0.0010
Certified		**0.29**		**0.0012**		**0.076**		**22.54**		**1.52**		**1.00**		**0.0075**		**0.19**		**15.5**		**0.018**
Uncertainty		0.01		0.0003		0.005		0.09		0.03		0.05		0.0009		0.01		0.1		0.001
Tolerance		0.03		0.0009		0.015		0.27		0.09		0.15		0.0027		0.03		0.3		0.003

Analysis	*	**Ni**	*	**O**	*	**S**
1	**16**	[58.469833]	**2**	0.000633	**11**	0.0005
2	**14**	58.5033333	**2**	0.000767	**1**	0.00053
3	**16**	[58.6]	**2**	0.000807	**12**	0.00053667
4	**4**	58.6466667	**2**	0.000867	**1**	0.000544
5	**6**	58.6693333	**2**	0.000877	**1**	0.00056667
6	**4**	58.6784667	**2**	0.000933	**1**	0.0006
7	**10**	58.75	**2**	0.001177	**1**	0.00086667
8	**16**	[58.75]	**2**	0.001267	**3**	0.0009
9	**16**	[58.76]	**2**	0.001313	**10**	0.0009
10	**10**	58.88	**2**	0.001333	**1**	0.0009
11	**4**	58.8925	**2**	0.001446	**1**	0.00092
12	**16**	[58.91]	**2**	0.002167	**1**	0.001
13	**16**	[59.0633]			**3**	0.00113333
14					**1**	0.00113333
Average		58.736421		0.001111		0.000788
Std Dev		0.000088		0.000096		0.000085
H		0.13		0.00044		0.00039
U_1		0.13		0.00045		0.00040
t-statistic		2.18		2.20		2.16
U_2		0.29		0.0010		0.00086
U_3		0.081		0.00029		0.00023
Certified		**58.7**		**0.0011**		**0.0008**
Uncertainty		0.2		0.0003		0.0003
Tolerance		0.6		0.0010		0.0007

BS C-2000 * Code for method Reference values listed as weight percent

Analysis	*	C	*	Nb	*	P	*	Si	*	Ti	*	V	*	W
1	**3**	0.0013	**5**	0.012067	**12**	0.00236667	**4**	0.00703333	**5**	0.00123333	**3**	0.006	**3**	0.105
2	**1**	0.00156667	**4**	0.0121	**3**	0.0025	**11**	0.0074	**5**	0.00176667	**5**	0.00803333	**14**	0.10966667
3	**3**	0.00183333	**5**	0.012167	**5**	0.0033	**3**	0.0076	**5**	0.00196667	**3**	0.0088	**11**	0.11
4	**1**	0.002	**12**	0.015667	**4**	0.0034	**12**	0.00903333	**3**	0.0033	**4**	0.00893333	**4**	0.11026667
5	**1**	0.00206333	**4**	0.015833	**4**	0.00346667	**10**	0.0103	**4**	0.00336667	**4**	0.00916667	**4**	0.125
6	**1**	0.00206667	**3**	0.017	**7**	0.00358667	**4**	0.0117	**14**	0.0041	**4**	0.00942	**4**	0.18633333
7	**11**	0.0024	**4**	0.017967	**4**	0.00363333	**4**	0.0126	**4**	0.00426667	**4**	0.00946	**4**	0.18766667
8	**1**	0.00243	**11**	0.0192	**3**	0.00493333	**4**	0.01296667	**10**	0.0044	**10**	0.0097	**4**	0.197
9	**1**	0.003563	**4**	0.019867	**10**	0.0050	**5**	0.0138	**4**	0.00453333	**5**	0.00970333	**5**	0.19766667
10	**1**	0.0037	**10**	0.0208	**4**	0.00506667	**4**	0.01386667	**11**	0.0051	**14**	0.01033333	**4**	0.20606667
11	**1**	0.00493333	**3**	0.021667	**4**	0.00626667	**4**	0.01413333	**3**	0.00546667	**4**	0.01093333	**4**	0.21119
12	**1**	0.005	**4**	0.022193					**4**	0.00664667	**5**	0.01216667		
13	**1**	0.005325	**14**	0.027667							**12**	0.01266667		
14	**1**	0.00536667									**11**	0.013		
15	**1**	0.005967									**4**	0.01363333		
Average				0.01910						0.00376		0.00996		0.1535
Std Dev				0.00081						0.00014		0.00040		0.0038
H				0.0014						0.00072		0.0011		0.0039
U_1				0.0017						0.00073		0.0012		0.0055
t-statistic				2.18						2.20		2.14		2.23
U_2				0.0036						0.0016		0.0025		0.012
U_3				0.0010						0.00046		0.00064		0.0037
Reference		**<0.008**		**0.02**		**<0.01**		**<0.03**		**0.004**		**0.011**		**0.15**
Uncertainty				0.01						0.002		0.003		0.05
Tolerance				0.02						0.003		0.009		0.14

BS C-2000 * Code for method Informational values listed as weight percent

Analysis	*	B	*	Ca	*	Pb	*	Sb	*	Sn	*	Ta	*	Zr
1	**12**	0.0000873	**12**	0.000017	**12**	0.000013	**5**	0.0000533	**12**	0.00017667	**5**	0.000007	**5**	0.00003
2	**7**	0.0002	**11**	0.0003	**5**	0.0000233	**12**	0.0000873	**5**	0.00018	**5**	0.00007	**12**	0.0000517
3	**4**	0.0005	**3**	0.0005	**3**	0.000036	**5**	0.00010	**5**	0.00020	**11**	0.001	**4**	0.00083
4	**3**	0.00053333	**4**	0.001103	**11**	0.0001	**9**	0.00023333	**11**	0.0003	**4**	0.00199	**3**	0.0011
5	**4**	0.00106667	**4**	0.002333	**4**	0.00086667	**5**	0.0004	**3**	0.0006	**4**	0.00663333	**4**	0.00213333
6	**14**	0.00136667			**9**	0.00103333	**9**	0.0006	**9**	0.0006			**11**	0.0023
7	**11**	0.0023					**4**	0.00106667	**4**	0.0015			**10**	0.0044
8							**11**	0.0014					**4**	0.00773333
9							**3**	0.0016						
Average		0.0009		0.0009		0.00035		0.00062		0.00051		0.002		0.002
Std Dev		0.0021		0.0024		0.00038		0.00099		0.00077		0.010		0.011
H		0.0004		0.0004		0.00029		0.0004		0.00033		0.001		0.001
U_1		0.0022		0.0025		0.00048		0.0010		0.00084		0.010		0.011
t-statistic		2.45		2.78		2.57		2.31		2.45		2.78		2.36
U_2		0.0053		0.0069		0.0012		0.0024		0.0020		0.028		0.025
U_3		0.0020		0.0031		0.00050		0.00081		0.00077		0.013		0.0090
Informational		(0.0009)		(0.0009)		(0.0003)		(0.0006)		(0.0005)		(0.002)		(0.002)

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 C-2000 * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ga	*	Ge	*	In	*	Ir	*	Os	*	Pt	*	Re	*	U	*	Zn
1	**12**	28	**12**	0.15	**12**	0.42	**12**	0.02	**12**	0.05	**12**	0.14	**12**	20	**12**	0.009	**12**	0.26
2	**12**	30	**12**	0.16	**12**	0.44	**12**	0.02	**12**	0.05	**12**	0.15	**12**	21	**12**	0.009	**12**	0.27
3	**12**	30	**12**	0.17	**12**	0.44	**12**	0.02	**12**	0.06	**12**	0.15	**12**	21	**12**	0.010	**12**	0.28

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

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, 17034
NSL Analytical	Cleveland, OH	ANAB	17025
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
Analytical Process Laboratories	Milwaukee, WI	A2LA	17025
Element Materials Technology	Huntington Beach, CA	A2LA	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Luvak Inc.	Boylston, MA	PRI	17025
Vitkovice Testing Center	Ostrava, Czech	ILAC	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025

A2LA = American Association for Laboratory Accreditation
ANAB = ANSI-ASQ National Accreditation Board
CNAS = China National Accreditation Service
ILAC = International Laboratory Accreditation Cooperation
NABL = National Accreditation Board for Testing and Calibration Laboratories
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: 215XHC5V, 215XHC6A; AR 612B, 614A, 637, 644, 645, 649, 650, 651, 654, 659, 662, 668, 673, 675, 870, 881, 882, 891, 892, 946, 1647, 1650, 1653; BAS 346A, 351, 363, 387; BS H1A, H1B, H1C, H-2, H230, H2C, H2E, H3A, H3B, H3C, H4A, H5, H6, H6A, H7, H8, 199B, 200-1, 200A, 617, 625A, 625C, 625D, 625E, 690A, 718, 718D; DSZU CA01A, CA013; IARM 54B, 54G, 56C, 188A, 189A, 190A, 329A, 338A; LECO 502-870; SRM C2402, 882.

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: 215XHC5V, 215XHC6A; BAS 351; BS H1A, H1B, H1C, H2C, H2E, H3B, H4A, H5, H6, H7, H8, 617, 625A; DSZU CA01A, CA013; IARM 189A, 329A, 338A; LECO 502-870; SRM C2402, 882.

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 C-2000 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 American Special Metals; Miami, FL.

Form: This CRM is machined in the form of a disc, approximately 38mm in diameter and 19mm 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 C-2000-020121. 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 17025:2017 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 35:2017 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 February 01, 2021.

Beau R. Brammer

President