Brammer Standard Company, Inc.

Certificate of Analysis
BS H1C

Certified Reference Material for Hastelloy type B-2 - UNS Number N10665

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]			Certified Value[1]	Estimate of Uncertainty[2]
Al	0.15	0.01		Mn	0.51	0.01
C	0.0022	0.0004		Mo	27.2	0.3
Cr	0.70	0.02		Ni	69.8	0.2
Fe	1.29	0.02				

Reference Values[3,4]

	Reference Value[1]	Estimate of Uncertainty[2]			Reference Value[1]	Estimate of Uncertainty[2]
P	0.0049	0.0003				

Informational Values[3,5]

As	(0.001)	B	(0.001)	Ca	(0.001)	Co	(0.01)	Cu	(0.002)
Mg	(0.0012)	N	(0.0005)	Nb	(0.009)	O	(0.0009)	Pb	(0.00002)
S	(0.0004)	Si	(0.01)	Sn	(0.002)	Ta	(0.009)	Ti	(0.008)
V	(0.02)	W	(0.009)	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] 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 Ba, Nd, Se, Te, 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 H1C   * Code for method   Certified values listed as weight percent

Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895
Telephone: (281) 440-9396   Fax: (281) 440-4432   Website: www.brammerstandard.com

Analysis	*	Al	*	C	*	Cr	*	Fe	*	Mn	*	Mo	*	Ni
1	14	0.131667	1	0.0009	10	0.606667	10	1.236667	3	0.458	4	26.7	16	[69.10333]
2	4	0.131833	1	0.001667	4	0.670667	4	1.259	4	0.484667	4	26.72	10	69.301
3	3	0.132	1	0.001833	13	0.679	3	1.26	4	0.494333	4	26.833	3	69.33667
4	5	0.1400	1	0.002133	4	0.683333	3	1.27	4	0.494333	10	26.99667	10	69.60
5	10	0.15	1	0.002367	4	0.692333	4	1.276667	8	0.496	3	27.19	13	69.63967
6	3	0.150333	1	0.002467	10	0.694	14	1.2800	3	0.50	4	27.2108	16	[69.64]
7	12	0.153333	1	0.002467	10	0.70	4	1.28	10	0.508	14	27.23333	4	69.72
8	4	0.154667	1	0.002523	4	0.703333	4	1.280333	3	0.508433	10	27.38	4	69.75333
9	4	0.156667	1	0.002833	10	0.713333	4	1.292	4	0.51	3	27.425	14	69.76667
10	4	0.160333	3	0.002867	4	0.721633	4	1.296667	10	0.513	4	27.50	3	69.84797
11	4	0.164667			3	0.7256	10	1.296667	4	0.514	4	27.54333	10	69.87
12	5	0.167333			3	0.754667	3	1.2987	10	0.516	10	27.56	16	[69.9283]
13	3	0.17			4	0.773667	10	1.30	4	0.517167	3	27.61667	10	70.22667
14	10	0.171333					12	1.3000	14	0.521	4	27.63333	16	[70.49667]
15	4	0.194333					4	1.318333	4	0.523267			4	70.56333
16							4	1.33	4	0.529			4	70.73333
17							4	1.34	4	0.53				
18									10	0.533333				
19									3	0.535				
Average		0.1530		0.00221		0.7093		1.289120		0.5106		27.22		69.840
Std dev		0.0033		0.00010		0.0089		0.000077		0.0047		0.10		0.048
H		0.0030		0.00042		0.008		0.012		0.0064		0.15		0.38
U_1		0.0044		0.00043		0.012		0.012		0.0080		0.19		0.38
t-statistic		2.14		2.26		2.18		2.12		2.10		2.16		2.13
U_2		0.010		0.0010		0.026		0.026		0.017		0.40		0.81
U_3		0.0025		0.00031		0.0073		0.0063		0.0038		0.11		0.20
Certified		**0.15**		**0.0022**		**0.70**		**1.29**		**0.51**		**27.2**		**69.8**
Uncertainty		**0.01**		**0.0004**		**0.02**		**0.02**		**0.01**		**0.3**		**0.2**
Tolerance		0.03		0.0010		0.06		0.06		0.03		0.9		0.8

BS H1C   * Code for method   Reference values listed as weight percent

Analysis	*	P
1	12	0.0021333
2	5	0.0034667
3	4	0.00351
4	5	0.00384
5	10	0.0043
6	3	0.0046667
7	3	0.0052
8	4	0.0052
9	4	0.0053333
10	4	0.0057
11	14	0.0059333
12	5	0.0061
13	4	0.0063
14	10	0.0064333
Average		0.004865
Std dev		0.000085
H		0.00055
U_1		0.00056
t-statistic		2.16
U_2		0.0012
U_3		0.00032
Reference		**0.0049**
Uncertainty		**0.0003**
Tolerance		0.0012

BS H1C   * Code for method   Informational values listed as weight percent

Analysis	*	As	*	B	*	Ca	*	Co	*	Cu	*	Mg	*	N	*	Nb
1	12	0.000006	12	0.000507	12	0.000017	12	0.0067	12	0.0003	4	0.00083	2	0.000117	12	0.0000533
2	5	0.0024	4	0.0006	3	0.00054	4	0.007103	5	0.0005567	5	0.001133	2	0.000133	5	0.00009967
3			7	0.000607	4	0.000767	4	0.0074	5	0.0015	5	0.0012	2	0.000493	5	0.0001
4			4	0.0010	4	0.0043	5	0.0075	10	0.0022	5	0.001233	2	0.0005	4	0.0016667
5			4	0.001167			4	0.0081	3	0.0028667	12	0.0014	2	0.000513	4	0.002
6			3	0.001233			5	0.0089	3	0.003	14	0.001567	2	0.000688	4	0.0053333
7			3	0.00205			3	0.008933	14	0.0031			2	0.000767	14	0.0136667
8			3	0.0021			5	0.0091	4	0.0058667			2	0.0009	3	0.0262
9			14	0.0024			4	0.013333							10	0.031
10			4	0.002767			10	0.020								
11							14	0.0228								
12							4	0.023033								
13							4	0.0241								
14							3	0.0353								
Average		0.0012		0.0014		0.0014		0.014		0.002		0.0012		0.00051		0.009
Std dev		0.0072		0.0044		0.0067		0.091		0.011		0.0043		0.00073		0.065
H		0.0003		0.0004		0.0004		0.001		0.0004		0.0003		0.00027		0.001
U_1		0.0072		0.0044		0.0067		0.091		0.012		0.0043		0.00078		0.065
t-statistic		12.71		2.26		3.18		2.16		2.36		2.57		2.36		2.31
U_2		0.092		0.010		0.021		0.20		0.027		0.011		0.0019		0.15
U_3		0.065		0.0032		0.011		0.053		0.0096		0.0045		0.00066		0.050
(Informational)		(0.001)		(0.001)		(0.001)		(0.01)		(0.002)		(0.0012)		(0.0005)		(0.009)

Analysis	*	O	*	Pb	*	S	*	Si	*	Sn	*	Ta	*	Ti	*	V
1	1	0.00037	12	0.000017	12	0.000068	5	0.0046	4	0.001833	4	0.005267	4	0.0005	12	0.000049
2	1	0.000511			1	0.0001	12	0.0065			3	0.0121	5	0.000687	4	0.0002
3	1	0.000533			1	0.000207	4	0.007					12	0.000703	4	0.001433
4	1	0.00055			1	0.000233	5	0.0077					5	0.0050	3	0.0051
5	1	0.000563			1	0.0004	4	0.009533					4	0.0055	14	0.005467
6	1	0.000633			1	0.000467	4	0.012033					4	0.013633	4	0.0071
7	1	0.000867			1	0.000567	4	0.016333					3	0.015	4	0.023333
8	1	0.0015			3	0.0013	3	0.017067					4	0.015033	3	0.0881
9	1	0.002333					14	0.0249					14	0.0157		
10							4	0.025167								
11							3	0.0254								
Average		0.0009		0.00001700		0.00042		0.01		0.002		0.01		0.01		0.02
Std dev		0.0019		0.00000056		0.00048		0.10		0.021		0.13		0.11		0.14
H		0.0003		0.000175		0.0003		0.0007		0.0004		0.0007		0.0007		0.001008
U_1		0.0019		0.00018		0.00055		0.10		0.021		0.13		0.11		0.14
t-statistic		2.31		12.71		2.36		2.23		12.71		12.71		2.31		2.36
U_2		0.0045		0.0022		0.0013		0.22		0.26		1.71		0.26		0.32
U_3		0.0015		0.0022		0.00046		0.068		0.26		1.21		0.088		0.11
(Informational)		(0.0009)		(0.00002)		(0.0004)		(0.01)		(0.002)		(0.009)		(0.008)		(0.02)

BS H1C   * Code for method   Informational values listed as weight percent

Analysis	*	W	*	Zr
1	5	0.004867	12	0.000020
2	5	0.005167	4	0.001
3	12	0.005633	4	0.0011
4	4	0.006533	10	0.0013
5	4	0.0075	3	0.0015
6	4	0.01		
7	3	0.0137		
8	4	0.014067		
9	4	0.015067		
Average		0.009		0.0010
Std dev		0.068		0.0032
H		0.0007		0.000327
U_1		0.068		0.0032
t-statistic		2.31		2.78
U_2		0.16		0.0089
U_3		0.052		0.0040
(Informational)		**(0.009)**		**(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 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 H1C   * Code for analytical method   Trace analysis listed as mg/kg   (ppm)

Analysis	*	Ba	*	Nd	*	Se	*	Te	*	Zn
1	5	2	5	5	5	3	5	13	12	1.2

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

Laboratory	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Evans Analytical Group	Liverpool, NY	A2LA	17025
NSL Analytical	Cleveland, OH	ACLASS	17025
Dirats Laboratories	Westfield,MA	ACLASS	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Exova	Glendale Heights, Il	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	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: 13X32101A, 212X4003, 212X4003K, 212X4004, 212X4004K, 215XHB2F, 215XHB5K, 24X07001; LECO 501-501, 501-550, 501-566, 501-591, 501-644, 501-645, 501-646, 501-675, 501-676, 501-991, 501-992, 501-993, 502-348, 502-873; AR 645, 654, 673, 875, 892, 946, 1648, 1652, 1653; BAS 349, 351, 387, 451; BS H1, H1A, H1B, H2A, H2C, H2D, H6B, 200, 200-1, 200-2, 200-3, 400D, 750C; DSZU CA01A; IARM 16, 52A, 54B, 56C, 63A, 63C, 257A; IMZ 184; JSS GS-6; KMS LSCON-001; NCS NS11028; SRM 160B, 166C, 349, 349A, 865, 866, 867, 882, 1413, 3109A, 3114, 3150.

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 — LECO 501-676, 502-873; BAS 351; BS H2, H1A, H1B, H2A, H2C, H2D, 200; DSZU CA01A; KMS LCSON-001; NCS NS11028; SRM 106B, 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 H1C 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 VDM Metals USA, LLC; Reno, NV.

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 H1C-101016. 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 30:2015   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 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, 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 October 10, 2016.

Beau R. Brammer