

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS H6B

Certified Reference Material for Hastelloy C-22 - UNS Number N06022

	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	<b>Certified Values<sup>3</sup></b>	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	
<b>Al</b>	<b>0.23</b>	0.01		<b>V</b>	<b>0.0063</b>	0.0006
<b>B</b>	<b>0.0016</b>	0.0003		<b>W</b>	<b>3.20</b>	0.02
<b>Co</b>	<b>0.079</b>	0.002				
<b>Cr</b>	<b>22.3</b>	0.1				
<b>Cu</b>	<b>0.035</b>	0.001				
<b>Fe</b>	<b>3.45</b>	0.02				
<b>Mg</b>	<b>0.0010</b>	0.0003				
<b>Mn</b>	<b>0.226</b>	0.003				
<b>Mo</b>	<b>14.05</b>	0.06				
<b>N</b>	<b>0.0118</b>	0.0005				
<b>Ni</b>	<b>55.9</b>	0.2				
<b>O</b>	<b>0.0007</b>	0.0002				
<b>P</b>	<b>0.0054</b>	0.0007				
<b>S</b>	<b>0.0005</b>	0.0002				
<b>Ti</b>	<b>0.050</b>	0.001				

### Informational Values<sup>3,4</sup>

As (0.0015)      C (0.008)      Nb (0.1)      Sb (0.006)      Si (0.035)  
Sn (0.0007)

<sup>1</sup> 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.

<sup>2</sup> 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.

<sup>3</sup> Values are given in weight percent.

<sup>4</sup> Values in parentheses are not certified and are provided for information only.

Trace element information values for Ca, Ce, Cl, Ga, Hf, K, Na, Pb, Re, Ta, Th, Zn, and Zr 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 H6B

\* Code for method Certified values listed as weight percent

Analysis	*	Al	*	B	*	Co	*	Cr	*	Cu	*	Fe	*	Mg	*	Mn
1	4	0.21	4	0.0012	4	0.069433	10	21.26333	5	0.0303	4	3.29	5	0.000643	10	0.208
2	5	0.219267	5	0.0015	4	0.069767	10	21.90333	4	0.030667	4	3.355	12	0.00090	4	0.212
3	10	0.223	4	0.0016	5	0.069967	4	22.0	4	0.0308	4	3.36	4	0.000987	3	0.22
4	4	0.223333	12	0.0016	10	0.075	4	22.30067	8	0.031267	10	3.36	5	0.001	3	0.22325
5	3	0.2245	5	0.001683	4	0.077467	14	22.31	4	0.031767	4	3.376	5	0.001067	12	0.2250
6	3	0.227	7	0.00170	5	0.080133	13	22.34933	10	0.034	4	3.384	14	0.001433	14	0.225333
7	14	0.227667	4	0.002	8	0.080533	10	22.36	12	0.0360	10	3.40	5	0.001467	4	0.227467
8	5	0.229133	5	0.0020	4	0.080567	3	22.52	3	0.037	4	3.41325	3	0.001468	4	0.227667
9	4	0.236	14	0.003033	14	0.081367	4	22.56	4	0.037567	4	3.425			5	0.228233
10	4	0.239833			4	0.0827	4	22.58333	4	0.037867	4	3.432			10	0.232
11	10	0.261667			10	0.083333	4	22.59	14	0.037967	4	3.433			8	0.233333
12	4	0.268667							3	0.038175	4	3.45			4	0.234667
13	4	0.2736									10	3.47			4	0.2395
14	3	0.279333									4	3.480				
15											4	3.49				
16											4	3.4982				
17											4	3.519667				
18											4	3.528333				
Average		0.2311		0.001623		0.0785		22.258		0.03498		3.447		0.000975		0.2255
Std dev		0.0047		0.000092		0.0016		0.088		0.00080		0.020		0.000068		0.0043
H		0.0035		0.00034		0.00183		0.12		0.0012		0.024		0.00030		0.0034
U <sub>1</sub>		0.0058		0.00035		0.0024		0.15		0.0014		0.031		0.00030		0.0055
t-statistic		2.16		2.31		2.23		2.23		2.20		2.11		2.36		2.18
U <sub>2</sub>		0.013		0.00082		0.0054		0.33		0.0032		0.066		0.00072		0.012
U <sub>3</sub>		0.0034		0.00027		0.0016		0.10		0.00091		0.015		0.00025		0.0033
<b>Certified</b>		<b>0.23</b>		<b>0.0016</b>		<b>0.079</b>		<b>22.3</b>		<b>0.035</b>		<b>3.45</b>		<b>0.0010</b>		<b>0.226</b>
<b>Uncertainty</b>		<b>0.01</b>		<b>0.0003</b>		<b>0.002</b>		<b>0.1</b>		<b>0.001</b>		<b>0.02</b>		<b>0.0003</b>		<b>0.003</b>
Tolerance		0.01		0.0008		0.005		0.3		0.003		0.07		0.0007		0.012

Analysis	*	Mo	*	N	*	Ni	*	O	*	P	*	S	*	Ti	*	V
1	4	13.83333	2	0.009867	16	55.64333	2	0.000546	5	0.0031	1	0.0003	10	0.04667	4	0.0052
2	3	13.9	2	0.010275	4	55.7	2	0.000567	4	0.004667	12	0.00040	12	0.0480	12	0.0055
3	10	13.90	2	0.010767	16	55.82667	2	0.000567	4	0.004867	1	0.000434	4	0.048667	5	0.0055
4	14	13.92667	2	0.012	13	55.85733	2	0.000567	14	0.005433	1	0.00045	5	0.0488	14	0.006167
5	3	13.985	2	0.012067	3	55.91667	2	0.000575	10	0.006133	1	0.0005	4	0.049233	4	0.006367
6	4	14.02667	2	0.012167	16	55.9625	2	0.000663	3	0.006725	1	0.00055	4	0.049733	4	0.006793
7	4	14.044	2	0.0123	4	56.02333	2	0.000767			1	0.0006	5	0.0498	3	0.009067
8	4	14.06667	2	0.012633	16	56.23333	2	0.000833			1	0.000933	4	0.0509		
9	4	14.07333	2	0.012633	14	56.28	2	0.001167			1	0.000967	3	0.05185		
10	10	14.10333	2	0.012767	10	56.30667	2	0.001533			1	0.00104	10	0.052		
11	4	14.15333	2	0.012867	10	56.32							4	0.0521		
12	4	14.29813			4	56.51667							4	0.052533		
13					10	56.54							14	0.052833		
14													3	0.055		
15													3	0.0581		
16													10	0.068833		
Average		14.046		0.01176		55.95		0.000740		0.00541		0.00052		0.0504		0.00627
Std dev		0.039		0.00024		0.12		0.000062		0.00040		0.00003		0.0012		0.00031
H		0.080		0.00071		0.29		0.00027		0.00052		0.00025		0.00143		0.00055
U <sub>1</sub>		0.088		0.00075		0.32		0.00028		0.00066		0.00025		0.0019		0.00063
t-statistic		2.20		2.23		2.18		2.26		2.57		2.26		2.13		2.45
U <sub>2</sub>		0.19		0.0017		0.69		0.00064		0.0017		0.00058		0.004		0.0015
U <sub>3</sub>		0.056		0.00051		0.19		0.00020		0.00069		0.00018		0.001		0.00058
<b>Certified</b>		<b>14.05</b>		<b>0.0118</b>		<b>55.9</b>		<b>0.0007</b>		<b>0.0054</b>		<b>0.0005</b>		<b>0.050</b>		<b>0.0063</b>
<b>Uncertainty</b>		<b>0.06</b>		<b>0.0005</b>		<b>0.2</b>		<b>0.0002</b>		<b>0.0007</b>		<b>0.0002</b>		<b>0.001</b>		<b>0.0006</b>
Tolerance		0.19		0.0017		0.7		0.0006		0.0017		0.0005		0.004		0.0015

**BS H6B** \* Code for method Certified values listed as weight percent

Analysis	*	W
1	3	3.1675
2	4	3.19
3	4	3.196
4	4	3.196667
5	3	3.20
6	14	3.20
7	4	3.205333
8	10	3.223333
9	10	3.23
10	4	3.253333
11	4	3.27
Average		3.199
Std dev		0.026
H		0.023
U <sub>1</sub>		0.034
t-statistic		2.23
U <sub>2</sub>		0.076
U <sub>3</sub>		0.023
<b>Certified</b>		<b>3.20</b>
<b>Uncertainty</b>		<b>0.02</b>
<b>Tolerance</b>		<b>0.08</b>

**BS H6B** \* Code for method Informational values listed as weight percent

Analysis	*	As	*	C	*	Nb	*	Sb	*	Si	*	Sn
1	5	0.000173	3	0.0040	12	0.0750	5	0.0000467	5	0.0192	5	0.00014
2	12	0.00022	3	0.0048	5	0.092133	5	0.000081	4	0.019467	12	0.00016
3	15	0.000517	1	0.00495	4	0.106167	5	0.000095	5	0.024867	5	0.000163
4	5	0.0006	1	0.005507	10	0.110667	12	0.0001	12	0.0255	5	0.0002
5	5	0.001467	1	0.005633			4	0.0100	4	0.027533	5	0.000243
6	4	0.002533	1	0.006933			14	0.0108667	4	0.0301	5	0.000333
7	14	0.003067	1	0.007567			4	0.0110667	4	0.034967	9	0.002147
8	3	0.00315	1	0.0087			3	0.012025	3	0.038	3	0.0025
9			1	0.009325					4	0.044		
10			1	0.011103					3	0.0448		
11			1	0.01156					14	0.0472		
12			1	0.0117					4	0.059333		
13			1	0.01235								
Average		0.00147		0.0080		0.096		0.0055		0.035		0.000736
Std dev		0.00028		0.0024		0.071		0.0019		0.015		0.000094
H		0.00033		0.0006		0.002		0.0005		0.001		0.00027
U <sub>1</sub>		0.00043		0.0025		0.071		0.0020		0.015		0.00029
t-statistic		2.36		2.18		3.18		2.36		2.20		2.36
U <sub>2</sub>		0.0010		0.0055		0.23		0.0047		0.032		0.00069
U <sub>3</sub>		0.00036		0.0015		0.11		0.0017		0.0093		0.00024
<b>(Informational)</b>		<b>(0.0015)</b>		<b>(0.008)</b>		<b>(0.1)</b>		<b>(0.006)</b>		<b>(0.035)</b>		<b>(0.0007)</b>

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<sub>L</sub>), calculated from its standard deviation (S<sub>L</sub>) and its uncertainty estimate (U<sub>L</sub>), is used as the weight (W<sub>L</sub>) for its mean (M<sub>L</sub>). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U<sub>1</sub> is the combined uncertainty from homogeneity and labs. U<sub>2</sub> is U<sub>1</sub> times the coverage factor (95 % t-statistic). U<sub>3</sub> is U<sub>2</sub> 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<sub>3</sub> 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 H6B		* Code for analytical method																		
		Trace analysis listed as mg/kg (ppm)																		
Analysis	*	Ca	*	Ce	*	Cl	*	Ga	*	Hf	*	K	*	Na	*	Pb	*	Re	*	Ta
1	12	0.10	5	0.56	12	0.011	12	17	12	0.16	12	0.082	12	0.010	12	0.60	12	5.0	12	1.0
2	3	1.7	5	0.59			5	20							5	1.0	5	8.0		
3	3	1.9	5	0.59			5	20							5	1.0	5	8.0		
4	3	2					5	20							5	1.0	5	8.3		
5	3	2.1																		
6	4	9																		
7	4	9																		
8	4	9																		

  

Analysis	*	Th	*	Zn	*	Zr
1	5	0.50	12	1.0	12	5.0
2	5	0.50			4	13
3	5	0.50			4	13
4					4	14

**Analytical Method Codes:**

- |                           |                           |                           |
|---------------------------|---------------------------|---------------------------|
| 1 Combustion (ASTM E1019) | 7 Photometric             | 13 Titrimetric            |
| 2 Fusion (ASTM E 1019)    | 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
LECO Corporation	St. Joseph, MI	A2LA	17025
Dirats Laboratories	Westfield, MA	ACCLASS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Exova	Glendale Heights, IL	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
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 a lathe from representative samples for the certified portion of the lot in accordance with ASTM Standard Practice E 1806. 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: 24X07001, 28X7183; 501-501, 501-502, 501-566, 501-643, 501-644, 501-645, 501-646, 501-676, 501-952, 501-991, 501-993, 502-348, 502-402, 502-411, 502-414, 502-416, 502-494; AR 670, 875, 892, 946, 1653, 1656; BAS 345, 349, 351, 387; BS H2A, H2B, H2C, H2D, H6, HON-T, HT6308E, 197, 197B, 625A; ECRM 088-1, 284-2; IARM 54B, 56C, 62E, 65A, 190A; JS 200-2; SRM 349, 349A, 55D, 671-1, 672-2, 673-3, 862, 865, 866, 867, 1246, 1249, 1254A, 1263A, 2402, 3102A, 3107, 3109A, 3113, 3131A.

**Homogeneity:** This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the following Reference Materials — 501-416, 501-676, 501-991; BAS 351; BS H2A, H2B, H6, HON-T, HT6308E, 197, 197B, 625A; ECRM 088-1. 284-2.

**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 H6B 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 Special Metals, Huntington Alloys Corporation; Huntington, West Virginia

**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 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 H6B-091614. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://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](http://www.brammerstandard.com)**  
**14603 Benfer Road**  
**Houston, Texas 77069-2895 USA**              **Fax: (281) 440-4432**              **Email: [contact@brammerstandard.com](mailto: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](http://www.brammerstandard.com)**

## **References:**

Versions used were those available at the time of testing and characterization

- E 826            Standard Practice for Testing Homogeneity of a Metal Lot or Batch in Solid Form by Spark Atomic Emission Spectrometry
- E 1019         Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
- E 1806         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](http://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 September 16, 2014.

Beau R. Brammer