

Brammer Standard Company, Inc.

Certificate of Analysis

BS H6C

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

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values ³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.223	0.009	Mo	13.49	0.04
B	0.0012	0.0003	N	0.025	0.002
Co	0.13	0.04	Ni	57.7	0.5
Cr	21.3	0.03	O	0.0008	0.0003
Cu	0.055	0.005	Pb	0.0004	0.0002
Fe	3.43	0.09	S	0.0004	0.0002
Mn	0.31	0.06	W	3.11	0.07
	Reference Value ¹	Estimate of Uncertainty ²	Reference Values ^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
As	0.0010	0.0006	Si	0.019	0.009
C	0.003	0.001	Sn	<0.005	
Ca	<0.5		Ta	<0.05	
H	<0.0005		Ti	0.006	0.002
Mg	0.005	0.002	V	0.009	0.002
Nb	0.010	0.006	Zn	<0.005	
P	0.007	0.003	Zr	<0.005	
Sb	<0.005				

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.

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

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* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	B	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N	*	Ni
1	4	0.2056667	4	0.0008333	4	0.11003333	3	21.08	4	0.0517	4	3.28133333	8	0.277	4	13.126	2	0.0230333	16	[57.2133]
2	3	0.2133333	4	0.0010	4	0.1101	3	21.126667	4	0.0522333	4	3.30166667	4	0.287	4	13.451333	2	0.0239	13	57.473
3	4	0.2156667	5	0.0010	11	0.11325	4	21.20	4	0.0525333	4	3.39056667	10	0.29	4	13.453333	2	0.0247667	4	57.5433333
4	11	0.2185	4	0.0010	4	0.116	4	21.235	4	0.0526667	14	3.4	7	0.2923333	4	13.4829	2	0.0248667	4	57.6117667
5	7	0.2193333	3	0.0010	3	0.11675	4	21.293333	8	0.0529667	10	3.41	4	0.2963333	4	13.486967	2	0.0249667	4	57.6866667
6	4	0.2198	4	0.0011	4	0.128666667	4	21.297667	4	0.0532667	3	3.41333333	4	0.3001333	4	13.492667	2	0.0251667	16	[57.6890667]
7	10	0.22	14	0.0012	10	0.13	4	21.299467	4	0.0552667	4	3.42633333	4	0.3074	4	13.493333	2	0.0253667	4	57.7399667
8	4	0.2201	3	0.0014	4	0.1302	13	21.311567	3	0.0553333	3	3.4275	4	0.308	14	13.5	2	0.0256667	16	[57.7975]
9	4	0.2208333	7	0.0014533	8	0.140	14	21.333333	4	0.0560333	4	3.44006667	4	0.3099667	11	13.5025	2	0.0256667	16	[57.8]
10	14	0.221	5	0.0014633	4	0.140933333	11	21.35	14	0.0561	4	3.44133333	3	0.31025	4	13.505033	2	0.0265	14	57.8333333
11	3	0.22275	11	0.0015	14	0.145333333	13	21.427	3	0.056175	4	3.4445	14	0.313	10	13.51	2	0.0265	16	[57.84333]
12	5	0.230	4	0.0015	4	0.147	4	21.44	11	0.056425	11	3.4825	3	0.3163333	3	13.526667	2	0.0265667	16	[57.915]
13	4	0.2323333	3	0.0017	5	0.150	4	21.463967	10	0.057	4	3.5	4	0.3163667	3	13.665				
14	4	0.2378667			4	0.156	10	21.50	5	0.0576667	4	3.537	11	0.32075	4	13.711667				
15	4	0.2443333			4	0.172166667	4	21.587333	4	0.0593667	4	3.54566667	4	0.3223667						
16									4	0.0597333			5	0.330						
17													4	0.3696667						
Average		0.2230		0.001242		0.1339		21.329689		0.0550		3.429447		0.309931		13.491		0.02515		57.678858
Std Dev		0.0030		0.000088		0.0030		0.000082		0.0014		0.000082		0.000079		0.020		0.00092		0.000091
H		0.0048		0.00046		0.0037		0.069		0.0024		0.022		0.0057		0.051		0.0016		0.13
U ₁		0.0057		0.00047		0.0047		0.069		0.0028		0.022		0.0057		0.055		0.0019		0.13
t-statistic		2.14		2.18		2.14		2.14		2.13		2.14		2.12		2.16		2.20		2.20
U ₂		0.012		0.0010		0.010		0.15		0.0059		0.047		0.012		0.12		0.0041		0.29
U ₃		0.0031		0.00028		0.0026		0.038		0.0015		0.012		0.0029		0.032		0.0012		0.085
Certified		0.223		0.0012		0.13		21.3		0.055		3.43		0.31		13.49		0.025		57.7
Uncertainty		0.009		0.0003		0.04		0.03		0.005		0.09		0.06		0.04		0.002		0.5
Tolerance		0.027		0.0009		0.12		0.09		0.015		0.27		0.18		0.12		0.006		1.5

Analysis	*	O	*	Pb	*	S	*	W
1	2	0.0003333	5	0.000057	1	0.00006	4	2.9683333
2	2	0.0004	5	0.0002	1	0.0002	4	2.9873333
3	2	0.0006667	9	0.0004	1	0.000233333	4	3.0618333
4	2	0.00075	3	0.00055	1	0.000263333	4	3.0666667
5	2	0.0009167	9	0.0005667	1	0.000266667	11	3.085
6	2	0.0009333	4	0.0006	1	0.000333333	10	3.10
7	2	0.001			1	0.000566667	4	3.1001667
8	2	0.001025			11	0.000575	4	3.1012667
9	2	0.00103			3	0.00062	14	3.11
10	2	0.0010667			1	0.0007	3	3.1166667
11	2	0.0014667			3	0.001	3	3.1225
12							4	3.1233333
13							4	3.1263333
14							4	3.1832333
15							4	3.3409667
Average		0.000818		0.00040		0.000438		3.106242
Std Dev		0.000058		0.00013		0.000095		0.000082
H		0.00040		0.00031		0.00032		0.021
U ₁		0.00040		0.00033		0.00033		0.021
t-statistic		2.23		2.57		2.23		2.14
U ₂		0.00089		0.00085		0.00074		0.045
U ₃		0.00027		0.00035		0.00022		0.012
Certified		0.0008		0.0004		0.0004		3.11
Uncertainty		0.0003		0.0002		0.0002		0.07
Tolerance		0.0007		0.0003		0.0003		0.21

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* Code for method

Reference values listed as weight percent

Analysis	*	As	*	C	*	Ca	*	H	*	Mg	*	Nb	*	P	*	Sb	*	Si	*	Sn
1	5	0.0003467	11	0.001175	11	0.00000014	2	0.000075	14	0.0032667	5	0.0040	4	0.00396	5	0.000067	3	0.010875	5	0.00036
2	15	0.0004067	1	0.0020	4	0.1302			11	0.004	5	0.00463333	5	0.0046167	9	0.0001	4	0.012	5	0.00036667
3	5	0.0004667	1	0.002					4	0.00412	4	0.00467333	4	0.0048667	5	0.0001367	6	0.0122	5	0.00038
4	5	0.0009333	1	0.0020333					4	0.0052	5	0.00470333	4	0.0057	5	0.0002	11	0.012825	3	0.001575
5	9	0.0014333	3	0.002425					3	0.0053	4	0.0092	4	0.0063667	4	0.0009	4	0.0130333	11	0.00165
6	4	0.0014667	1	0.0025433					5	0.0053333	4	0.01186667	4	0.0067333	4	0.0010667	4	0.0141667	4	0.00166667
7	3	0.0015	1	0.0026667					4	0.0058667	11	0.0125	10	0.007	4	0.0011	4	0.0184667	4	0.0020
8	4	0.0015	3	0.0027333					4	0.0074333	4	0.01596667	6	0.0070333	11	0.0011	4	0.0192333	4	0.0020
9			1	0.0027733					3	0.01666667	14	0.0071333	14	0.0071333			5	0.0220	9	0.0023
10			1	0.0033					3	0.01905	3	0.0074333					4	0.0253		
11			1	0.0048333									11	0.00775			4	0.0275667		
12			1	0.0071667									4	0.0077667			14	0.0289		
13			1	0.0072									4	0.009			4	0.0356667		
14													3	0.009225						
Average		0.001028		0.003296		0.0197		0.000075		0.00507		0.01033		0.006756		0.00058		0.019403		0.001351
Std Dev		0.000044		0.000088		0.0051		0.000030		0.00011		0.00010		0.000085		0.00011		0.000088		0.000045
H		0.00043		0.00068		0.0015		0.00018		0.00081		0.0011		0.00091		0.00035		0.0015		0.00048
U ₁		0.00043		0.00068		0.0053		0.00018		0.00082		0.0011		0.00092		0.00037		0.0015		0.00048
t-statistic		2.36		2.18		12.71		12.71		2.36		2.26		2.16		2.36		2.18		2.31
U ₂		0.0010		0.0015		0.067		0.0023		0.0019		0.0025		0.0020		0.00087		0.0032		0.0011
U ₃		0.00036		0.00041		0.047		0.0023		0.00068		0.00079		0.00053		0.00031		0.00088		0.00037
Reference		0.0010		0.003		<0.5		<0.0005		0.005		0.010		0.007		<0.005		0.019		<0.005
Uncertainty		0.0006		0.001						0.002		0.006		0.003				0.009		
Tolerance		0.0009		0.002						0.004		0.009		0.006				0.018		

Analysis	*	Ta	*	Ti	*	V	*	Zn	*	Zr										
1	5	0.00006	4	0.0042867	5	0.0060	5	0.00021	5	0.00027										
2	5	0.0010333	4	0.0043333	5	0.007066667														
3	3	0.00165	5	0.0049	14	0.007366667														
4	4	0.0039667	5	0.0050	5	0.008046667														
5	4	0.0042333	5	0.00508	4	0.008466667														
6	11	0.005925	4	0.0060333	11	0.00865														
7			3	0.0060333	3	0.008733333														
8			11	0.00605	4	0.008883333														
9			4	0.0060667	10	0.009														
10			3	0.0062	4	0.009														
11			10	0.008	4	0.009066667														
12			14	0.0122	3	0.0092														
13					4	0.010166667														
14					4	0.012														
15					4	0.012166667														
16					4	0.012566667														
Average		0.00281		0.006182		0.009149		0.00021		0.00027										
Std Dev		0.00013		0.000091		0.000079		0.00031		0.00055										
H		0.00064		0.00088		0.0010		0.000246		0.000268										
U ₁		0.00065		0.00088		0.0010		0.00040		0.00061										
t-statistic		2.57		2.20		2.13		12.71		12.71										
U ₂		0.0017		0.0019		0.0022		0.0051		0.0077										
U ₃		0.00068		0.00056		0.00056		0.0051		0.0077										
Reference		<0.05		0.006		0.009		<0.005		<0.005										
Uncertainty				0.002		0.002														
Tolerance				0.005		0.006														

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 its mean (M_L). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U₁ is the combined uncertainty from homogeneity and labs. U₂ is U₁ multiplied by the coverage factor (95 % t-statistic). U₃ is U₂ 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 U₃ 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.

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

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
NSL Analytical	Cleveland, OH	ANAB	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Shiva Analyticals Private Limited	Hoskote, Bangalore	NABL	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Luvak Inc.	Boylston, MA	PRI	17025
Raghavendra Spectro Metallurgical Laboratory	Karnataka, India	NABL	17025
Laboratory Testing, Inc.	Hatfield, PA	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
APL, Inc	Milwaukee, WI	A2LA	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
 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: 215XH6CA; AR 115C, 148, 644, 645, 659, 668, 673, 870, 882, 892, 911A, 945, 1650, 1651, 1653, 1658; BAS 387; BS C-2000, H1C, H2, H2B, H2C, H2D, H2E, H3C, H-6, H6A, H6B, H230, MP35N, 690A, 718D; DSZU CA01a; IARM 54B, 54G, 54H, 56C, 60B, 62E, 65B, 65D, 69D, 189A, 190A; IMZ 203; LECO 502-195, 502-348, 502-411, 502-712, 502-856, 502-903, 502-913, 502-918; SRM C2402, 349, 349A, 864, 866, 3135, 3162a; YSBC 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: 215XH6CA; BS H2A, H2B, H2D, H2E, H-6, H6b; SRM C2402.

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 H6C 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 Special Metals / Huntington Alloys Corporation; Huntington, WV.

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 H6C-072123. 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
Fax: (281) 440-4432

Web: www.brammerstandard.com
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 July 21, 2023.

Beau R. Brammer
President