

Brammer Standard Company, Inc.

Certificate of Analysis

BS H3D

Certified Reference Material for for Hastelloy X - UNS Number N06002

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
Al	0.14	0.02		N	0.021	0.001
B	0.0027	0.0006		Nb	0.40	0.05
C	0.067	0.004		Ni	47.5	0.3
Co	0.70	0.06		O	0.0007	0.0004
Cr	21.8	0.3		P	0.008	0.003
Cu	0.072	0.008		S	0.0004	0.0002
Fe	19.28	0.08		Si	0.28	0.04
H	0.0003	0.0001		Ti	0.046	0.005
Mn	0.63	0.03		V	0.019	0.005
Mo	8.46	0.09		W	0.58	0.04

	Reference Value ¹	Estimate of Uncertainty ²	Reference Values^{3,4}	Reference Value ¹	Estimate of Uncertainty ²	
As	<0.005			Sn	<0.005	
Mg	<0.005			Ta	<0.05	
Pb	<0.0005			Zn	<0.005	
Sb	<0.005			Zr	0.002	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 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 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.

BS H3D

* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	H	*	Mn	*	Mo	
1	10	0.13	5	0.0020	1	0.0609667	3	0.6436667	4	21.51333	11	0.0528	11	19.09	2	0.00022	7	0.598	4	8.348	
2	4	0.131	7	0.0022867	1	0.0629333	4	0.648	13	21.54367	5	0.06483333	4	19.1166667	2	0.000233	4	0.6036667	4	8.3836667	
3	10	0.1316667	4	0.0023	1	0.0655	4	0.6660667	4	21.65733	4	0.06703333	4	19.2076667	2	0.000267	15	0.6076667	4	8.3866667	
4	3	0.135	5	0.0023133	1	0.0656667	10	0.6683333	10	21.67	4	0.0701	4	19.24	2	0.000303	10	0.61	4	8.4193333	
5	4	0.135	4	0.00232	1	0.066	3	0.679	4	21.7221	10	0.071	10	19.2533333	2	0.000327	4	0.6103333	11	8.42	
6	4	0.138	4	0.0024	1	0.0663667	4	0.692	4	21.75667	4	0.071	4	19.2596667	2	0.00036	4	0.618	4	8.4399667	
7	3	0.1386667	3	0.0024	11	0.0666	14	0.6986667	4	21.76233	4	0.07103333	14	19.2666667	2	0.000367	4	0.6196667	4	8.4459	
8	4	0.14	3	0.0024	3	0.0666667	4	0.6999333	14	21.76667	14	0.0713	4	19.2867	2	0.000367	4	0.6218	4	8.4635667	
9	4	0.14	4	0.0026	1	0.068	4	0.7	13	21.77453	3	0.07233333	4	19.2966667	2	0.000387	4	0.6229667	14	8.47	
10	4	0.1400333	3	0.0028333	1	0.068	15	0.7006667	4	21.78667	4	0.07333333	4	19.30133333	2	0.0004	4	0.62423333	4	8.47	
11	4	0.1404333	4	0.0031333	1	0.0681	4	0.7014333	4	21.789	4	0.0739	4	19.3114			10	0.62533333	4	8.4708333	
12	4	0.1413333	14	0.0032333	3	0.0685	10	0.71	4	21.79587	3	0.07393333	4	19.32333333			3	0.63	4	8.4733333	
13	7	0.143	3	0.0034	1	0.0689	4	0.7126667	3	21.8	15	0.07393333	13	19.328			4	0.6301667	3	8.5066667	
14	14	0.1436667	11	0.0036	3	0.071	4	0.713	3	21.91667	10	0.07436667	3	19.33			4	0.632	10	8.51	
15	11	0.145			1	0.0713333	3	0.7233333	10	21.94	4	0.07443333	4	19.33093333			14	0.633	3	8.51	
16	3	0.1486667					4	0.7256	11	22.05	4	0.07463333	3	19.33333333			11	0.642	10	8.5666667	
17	5	0.1516667					11	0.732	3	22.07333	4	0.07606667	10	19.36			3	0.65			
18	4	0.1574667					4	0.7423333			3	0.0892	3	19.41333333			3	0.6526667			
19																		4	0.6926667		
Average		0.140589		0.002659		0.0669		0.697594		21.776		0.0716		19.280502		0.000320		0.627588		8.464	
Std Dev		0.000075		0.000085		0.0017		0.000075		0.057		0.0019		0.000075		0.000017		0.000073		0.014	
H		0.0038		0.00062		0.0026		0.0088		0.070		0.0027		0.065		0.00028		0.0083		0.038	
U ₁		0.0038		0.00063		0.0031		0.0088		0.090		0.0033		0.065		0.00028		0.0083		0.041	
t-statistic		2.11		2.16		2.14		2.11		2.12		2.11		2.11		2.26		2.10		2.13	
U ₂		0.0080		0.0014		0.0067		0.019		0.19		0.0070		0.14		0.00064		0.018		0.087	
U ₃		0.0019		0.00036		0.0017		0.0044		0.046		0.0016		0.032		0.00020		0.0040		0.022	
Certified		0.14		0.0027		0.067		0.70		21.8		0.072		19.28		0.0003		0.63		8.46	
Uncertainty		0.02		0.0006		0.004		0.06		0.3		0.008		0.08		0.0001		0.03		0.09	
Tolerance		0.06		0.0018		0.012		0.18		0.9		0.024		0.24		0.0002		0.09		0.27	

Analysis	*	N	*	Nb	*	Ni	*	O	*	P	*	S	*	Si	*	Ti	*	V	*	W
1	2	0.0203	3	0.357	10	47.296667	2	0.0002	4	0.005183	1	0.00013333	11	0.245	4	0.040333	4	0.01453333	3	0.5633333
2	2	0.0203333	4	0.383	4	47.40	2	0.0005	4	0.0053	1	0.0002	4	0.257333333	3	0.041	5	0.01526667	4	0.5655333
3	2	0.0206667	3	0.3833333	16	[47.4]	2	0.0005	4	0.005633	1	0.00026667	4	0.258366667	4	0.041567	5	0.01573333	10	0.57
4	2	0.0208333	3	0.385	16	[47.4]	2	0.0005333	5	0.005787	1	0.00028	4	0.260666667	11	0.0422	4	0.01613333	4	0.5703667
5	2	0.0209	10	0.394	16	[47.43]	2	0.00061	4	0.005967	1	0.0003	4	0.266	5	0.0434	3	0.0162	4	0.5725
6	2	0.0209333	4	0.3952333	13	47.469667	2	0.00061	4	0.006	1	0.00033333	14	0.267333333	3	0.0436	10	0.01713333	4	0.5776667
7	2	0.021	14	0.399	16	[47.47633]	2	0.0006767	10	0.006167	1	0.00043333	4	0.269966667	4	0.043967	14	0.01716667	4	0.5776667
8	2	0.0210333	4	0.4	4	47.499467	2	0.00109	3	0.006467	1	0.0005	10	0.271333333	4	0.0450	4	0.01806667	4	0.58
9	2	0.0213333	4	0.4005667	4	47.556967	2	0.0011333	14	0.009233	3	0.0005	6	0.2719	4	0.045	4	0.0185	4	0.5808667
10	2	0.0214667	4	0.4012	14	47.566667	2	0.001325	4	0.0099	11	0.0005	3	0.275333333	4	0.0453	3	0.01863333	14	0.5813333
11	2	0.0216	4	0.4073333	16	[47.6026]			6	0.010067	1	0.00061667	10	0.28	4	0.046867	4	0.0203	11	0.591
12			4	0.4148667	16	[47.7133]			4	0.010067			3	0.281666667	3	0.047033	4	0.021	10	0.600
13			4	0.4186667	4	47.76			3	0.0112			3	0.285	4	0.047067	3	0.02266667	4	0.6086667
14			4	0.4296667	16	[47.80667]			3	0.011333			4	0.290	4	0.048233	4	0.02403333	3	0.62
15			10	0.43					10	0.012			4	0.296333333	10	0.049	4	0.02406667		
16			11	0.434					11	0.0131			4	0.319	14	0.0525				
17			4	0.440									4	0.3218	10	0.052633				
Average		0.02091		0.404286		47.505516		0.00072		0.008338		0.000374		0.277473		0.045571		0.018629		0.582781
Std Dev		0.00082		0.000077		0.000088		0.00010		0.000079		0.000020		0.000077		0.000077		0.000082		0.000085
H		0.0015		0.0066		0.12		0.00038		0.010		0.00030		0.0054		0.0022		0.0014		0.0080
U ₁		0.0017		0.0066		0.12		0.00039		0.010		0.00030		0.0054		0.0022		0.0014		0.0080
t-statistic		2.23		2.12		2.16		2.26		2.13		2.23		2.12		2.12		2.14		2.16
U ₂		0.0038		0.014		0.25		0.00088		0.0021		0.00067		0.011		0.0046		0.0031		0.017
U ₃		0.0011		0.0034		0.067		0.00028		0.00053		0.00020		0.0028		0.0011		0.00079		0.0046
Certified		0.021		0.40		47.5		0.0007		0.008		0.0004		0.28		0.046		0.019		0.58
Uncertainty		0.001		0.05		0.3		0.0004		0.003		0.0002		0.04		0.005		0.005		0.04
Tolerance		0.004		0.15		0.9		0.0006		0.007		0.0003		0.12		0.015		0.015		0.12

BS H3D

* Code for method

Reference values listed as weight percent

Analysis	*	As	*	Mg	*	Pb	*	Sb	*	Sn	*	Ta	*	Zn	*	Zr
1	15	0.0010133	4	0.0012467	5	0.0000313	5	0.00026	5	0.00079	5	0.00055667	5	0.00024	4	0.001367
2	5	0.00127										5	0.0006		3	0.0015
3												5	0.00376667		4	0.001667
4												4	0.007		4	0.0019
5												4	0.00886667		11	0.0022
6															10	0.002267
Average		0.00111		0.00125		0.0000313		0.000257		0.00079		0.00416		0.00024		0.00189
Std Dev		0.00012		0.00020		0.0000054		0.000050		0.00010		0.00014		0.00044		0.00011
H		0.00044		0.00046		0.00014		0.00026		0.00039		0.00075		0.00026		0.0080
U ₁		0.00046		0.00050		0.00014		0.00027		0.00040		0.00076		0.00051		0.0080
t-statistic		12.71		12.71		12.71		12.71		12.71		2.78		12.71		2.570582
U ₂		0.0058		0.0064		0.0018		0.0034		0.0051		0.0021		0.0064		0.021
U ₃		0.0041		0.0064		0.0018		0.0034		0.0051		0.00094		0.0064		0.0084
Reference		<0.005		<0.005		<0.0005		<0.005		<0.005		<0.05		<0.005		0.002
Uncertainty																0.001
Tolerance																0.001

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
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Shiva Analyticals Private Limited	Hoskote, Bangalore	NABL	17025
Dirats Laboratories	Westfield, MA	ANAB	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
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	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: AR 115C, 148, 511, 546, 614A, 645, 659, 668, 673, 870, 882, 890, 896, 945, 1650, 1651, 1653, 1658; BAS387; BS C-2000, H1C, H230, H2C, H2E, H-3, H3A, H3B, H3C, H-4, H4A, H4B, H6B, HON T, MP35N, 690A, 718D, 6255; DSZU CA01a; IARM 54H, 56A, 56C, 56H, 60B, 62E, 69A, 69C, 69D, 154B, 189A, 229, 338A; IMZ 203; JSS GS-1d; LECO 501-502, 502-195, 502-411, 502-712, 502-855, 502-856, 502-869, 502-903, 502-913, 502-935, 762-747; NCS NS11079; SRM 349, 865, 866, 3155.

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: BS H-3, H3A, H3B, H-4, H4A, H4B, 6255.

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 H3D 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 H3D-071923. 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 19, 2023.

Beau R. Brammer

President