

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS H-13

Certified Reference Material for H-13 Tool Steel - UNS Number T20813

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0152	0.0008		Ni	0.002
As	0.0066	0.0004		O	0.0004
C	0.402	0.005		P	0.0005
Co	0.0092	0.0005		S	0.0007
Cr	5.14	0.03		Sb	0.0005
Cu	0.197	0.003		Si	0.01
Fe	[90.4]	0.7		Sn	0.0004
Mn	0.386	0.004		V	0.01
Mo	1.24	0.01		W	0.0005
N	0.0108	0.0006			
	Certified Value ¹	Estimate of Uncertainty ²	Reference Values^{3,5}	Certified Value ¹	Estimate of Uncertainty ²
Nb	0.0004	0.0002		Ti	0.0009

Informational Values^{3,5}

B (0.0002) Ca (0.0003) Mg (0.0002) Pb (0.0003) Ta (0.003)
Zr (0.0014)

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.

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 Cd, Ce, Cl, Ga, Ge, Hf, K, La, Na, Re, 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.

Analysis	* Al	* As	* C	* Co	* Cr	* Cu	* Fe	* Mn
1	5 0.013633	4 0.005633	1 0.394333	5 0.007933	14 5.113333	3 0.185667	16 90.23233	4 0.367
2	12 0.0140	12 0.0058	1 0.397067	3 0.0083	13 5.115	10 0.188667	10 90.34333	4 0.3688
3	4 0.0140	15 0.006033	1 0.397667	4 0.008567	4 5.123333	5 0.192633	3 90.37	3 0.37
4	5 0.0148	5 0.0063	1 0.398	4 0.008567	4 5.148	4 0.194667	4 90.40667	10 0.37
5	14 0.0155	5 0.006333	1 0.39875	8 0.00911	10 5.16	4 0.1960	16 90.425	10 0.378667
6	4 0.0156	5 0.0064	1 0.4005	5 0.009233	3 5.16	3 0.196	4 90.43333	3 0.380667
7	3 0.0157	10 0.0068	1 0.400667	12 0.0093	3 5.17	10 0.196	16 90.43333	4 0.381
8	5 0.0158	9 0.00705	1 0.4011	4 0.009483	3 5.17	4 0.196667	16 90.45	4 0.381333
9	10 0.016067	4 0.007733	1 0.404667	5 0.0095	4 5.171767	8 0.197667	4 0.384667	4 0.384667
10	4 0.016133	14 0.0083	1 0.407567	14 0.0095	4 5.176667	14 0.198667	4 0.385333	4 0.385333
11	3 0.017	3 0.00835	1 0.408333	5 0.010367	10 5.18	4 0.199633	4 0.389	4 0.389
12			3 0.4085		4 5.215	3 0.20	14 0.389667	14 0.389667
13			3 0.41		4 5.23	4 0.201	4 0.390767	4 0.390767
14						4 0.205333	5 0.391567	5 0.391567
15							3 0.394	3 0.394
Average	0.01516	0.00656	0.4020	0.00924	5.142	0.1970	90.42	0.3864
Std dev	0.00097	0.00029	0.0072	0.00035	0.034	0.0047	0.71	0.0064
H	0.0008	0.00056	0.0051	0.00064	0.034	0.0032	0.48	0.0049
U ₁	0.0013	0.00063	0.0088	0.00073	0.048	0.0057	0.85	0.0081
t-statistic	2.23	2.23	2.18	2.23	2.18	2.16	2.36	2.14
U ₂	0.0028	0.0014	0.019	0.0016	0.11	0.012	2.01	0.017
U ₃	0.00084	0.00042	0.0053	0.00049	0.029	0.0033	0.71	0.0045
Certified	0.0152	0.0066	0.402	0.0092	5.14	0.197	[90.4]	0.386
Uncertainty	0.0008	0.0004	0.005	0.0005	0.03	0.003	0.7	0.004
Tolerance	0.0028	0.0014	0.019	0.0016	0.11	0.012	2.0	0.017

Analysis	* Mo	* N	* Ni	* O	* P	* S	* Sb	* Si
1	4 1.210367	2 0.010567	4 0.103667	2 0.001533	4 0.0092	12 0.0180	4 0.001467	4 0.964667
2	7 1.216333	2 0.0106	3 0.1065	2 0.00153	5 0.0093	1 0.0183	5 0.001533	6 0.98
3	4 1.22	2 0.010667	4 0.107133	2 0.0016	4 0.0093	1 0.019167	5 0.002133	6 0.981667
4	3 1.23	2 0.010867	4 0.107667	2 0.0021	5 0.009733	1 0.0192	5 0.0022	4 0.989333
5	4 1.234	2 0.010933	4 0.107667	2 0.002533	12 0.0100	1 0.019667	12 0.0023	4 0.990933
6	10 1.24	2 0.01108	5 0.108333	2 0.002867	10 0.0101	10 0.0198	4 0.992333	4 0.992333
7	3 1.24	2 0.011233	4 0.1086		4 0.010167	3 0.0200	4 0.9950	4 0.9950
8	4 1.243	2 0.01164	12 0.1100		7 0.010167	1 0.020433	3 1.00	3 1.00
9	4 1.2456		3 0.11		3 0.01065	1 0.0207	10 1.00	10 1.00
10	3 1.246667		5 0.110167		13 0.010833	3 0.02075	3 1.005	3 1.005
11	4 1.248		8 0.112		4 0.0110	1 0.020833	3 1.06667	3 1.06667
12	4 1.263333		14 0.115		3 0.0110	1 0.021367	10 1.01	10 1.01
13	10 1.27		3 0.116667		4 0.0110	1 0.0214	14 1.018567	14 1.018567
14					10 0.011033			
15					14 0.0119			
16					3 0.012			
Average	1.244	0.01077	0.1093	0.00182	0.01031	0.02018	0.00202	0.988
Std dev	0.016	0.00030	0.0028	0.00017	0.00066	0.00057	0.00020	0.019
H	0.011	0.00068	0.0022	0.00035	0.00067	0.0009	0.00036	0.009
U ₁	0.019	0.00075	0.0036	0.00039	0.00094	0.0011	0.00041	0.021
t-statistic	2.18	2.36	2.18	2.57	2.13	2.18	2.78	2.18
U ₂	0.042	0.0018	0.0078	0.0010	0.0020	0.0023	0.0011	0.046
U ₃	0.012	0.00063	0.0022	0.00041	0.00050	0.00065	0.00051	0.013
Certified	1.24	0.0108	0.109	0.0018	0.0103	0.0202	0.0020	0.99
Uncertainty	0.01	0.0006	0.002	0.0004	0.0005	0.0007	0.0005	0.01
Tolerance	0.04	0.0018	0.008	0.0010	0.0020	0.0023	0.0011	0.05

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* Code for method

Certified values listed as weight percent

Analysis	*	Sn	*	V	*	W
1	5	0.007833	4	0.964667	12	0.0020
2	5	0.008833	10	0.970	4	0.002
3	4	0.0089	3	0.97	5	0.0021
4	5	0.008967	3	0.974	4	0.0023
5	5	0.009133	4	0.977133	5	0.002467
6	12	0.0092	4	0.981067		
7	9	0.0092	4	0.986333		
8	5	0.0095	4	0.988		
9	4	0.00962	4	0.989		
10	9	0.0098	4	0.992		
11	3	0.01				
12	10	0.0103				
13	3	0.01065				
Average		0.00929		0.976		0.00221
Std dev		0.00028		0.014		0.00022
H		0.00064		0.009		0.00037
U ₁		0.00070		0.017		0.00043
t-statistic		2.18		2.26		2.78
U ₂		0.0015		0.038		0.0012
U ₃		0.00042		0.012		0.00053
Certified		0.0093		0.98		0.0022
Uncertainty		0.0004		0.01		0.0005
Tolerance		0.0015		0.04		0.0012

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* Code for method

Reference values listed as weight percent

Analysis	*	Nb	*	Ti
1	5	0.00014	12	0.0013
2	5	0.0002	4	0.001367
3	5	0.000333	5	0.0015
4	5	0.00043	5	0.001567
5	4	0.000633	5	0.001667
6	4	0.0010	4	0.002657
7	12	0.0014	3	0.00275
8	14	0.002233	4	0.002767
9	3	0.00535	14	0.002767
10	4	0.0080		
Average		0.000427		0.00194
Std dev		0.000068		0.00013
H		0.00023		0.00035
U ₁		0.00024		0.00038
t-statistic		2.26		2.31
U ₂		0.00054		0.00087
U ₃		0.00017		0.00029
Reference		0.0004		0.0019
Uncertainty		0.0002		0.0009
Tolerance		0.0005		0.0009

Analysis	*	B	*	Ca	*	Mg	*	Pb	*	Ta	*	Zr
1	12	0.000092	4	0.0001	5	0.0000933	5	0.000012	5	0.001633	12	0.0010
2	5	0.00011	14	0.000233	5	0.0001	5	0.00008	3	0.0064	4	0.001567
3	4	0.000133	3	0.00028	12	0.00012	5	0.000127	14	0.007683	14	0.001933
4	7	0.000163	4	0.000333	14	0.00013	9	0.000657			3	0.0025
5	4	0.0002	4	0.000343	3	0.000155	9	0.0017			4	0.0026
6	14	0.0007	4	0.000433	4	0.000167	9	0.0025				
7	3	0.00072	4	0.000607	5	0.000233						
8			4	0.00065	5	0.0003						
9			12	0.00085	4	0.000377						
Average		0.000165		0.000306		0.000165		0.000307		0.00254		0.00135
Std dev		0.000022		0.000031		0.000013		0.000029		0.00038		0.00017
H		0.00019		0.00021		0.00019		0.00021		0.00039		0.00032
U ₁		0.00019		0.00022		0.00019		0.00022		0.00055		0.00036
t-statistic		2.45		2.31		2.31		2.57		4.30		2.78
U ₂		0.00047		0.00050		0.00044		0.00056		0.0024		0.0010
U ₃		0.00018		0.00017		0.00015		0.00023		0.0014		0.00045
Informational		(0.0002)		(0.0003)		(0.0002)		(0.0003)		(0.003)		(0.0014)

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 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 times 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 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.

Analysis	*	Cd	*	Ce	*	Cl	*	Ga	*	Ge	*	Hf	*	K	*	La	*	Na	*	Re	
1	4	2	5	0.21	12	0.15	12	9	5	12	12	0.64	12	0.3	4	4	12	0.18	12	0.67	
2	4	2	5	0.21			5	11	5	12										5	1.4
3	4	2	5	0.28			5	11	5	12										5	1.4
4			4	7			5	11	12	20										5	1.4

Analysis	*	Zn
1	12	0.39
2	4	29

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
Dirats Laboratories	Westfield, MA	ACCLASS	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Exova	Glendale Heights, IL	A2LA	17025
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Shiva Analyticals	Hoskote, Bangalore	NABL	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025

A2LA = American Association for Laboratory Accreditation

ACCLASS = ANSI-ASQ National Accreditation Board

CNAS = China National Accreditation Service

NABL = National Accreditation Board for Testing and Calibration Laboratories

Nadcap = National Aerospace and Defense Contractors Accreditation Program

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 E 1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025. Methods of analysis used were those listed on this page.

Traceability: The following Certified Reference Materials were used to validate the analytical data listed on pages 2-4 — AR 646, 657, 660, 676, 875, 878, 1651, 1653, 1656; BAS 087/1, 276/1, 407, 410/2, 435, 456, 460, 464/1; BS CSN 2-1, CSN 4, TH-12, TS-7, 30D, 34B, 34C, 49, 56H, 61G, 1030; CKD 188A; ECRM 037/1, 85/1, 86/1, 87/1, 276/2D, 284/1, 285/1, 287/1, 327/2; IARM 35H, 39B, 42A, 42B, 242A, 255A, 259A; IMZ 1.8/3, 112, 119, 159; JK 47; KMS HOCS-001; SRM 10G, 13F, 30F, 55D, 72F, 73B, 133A, 139B, 160B, 293, 361, 362, 363, 1246, 1263A, 1763, 1766, 3108, 3109A, 3110, 3127A, 3161A, 3163, 3168A, 3169; 12x349, 12x356, 12x357, 12x10180; 501-102, 501-320, 501-501, 501-502, 501-504, 501-506, 501-643, 501-644, 501-676, 501-677, 501-993, 502-102, 502-194, 502-416.

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 — BS CSN 2-1, CSN 4, 0021, SS4951, 0022, 0121P, 0122P, 89D, 98, 410B; BAS 475; ECRM 096/1, 327/2, 284/1, 285/1; KMS HOCS-001; 502-416.

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 H-13 is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Source: The bar stock for this CRM was purchased from Southern Tool Steel, Inc, Hixson, TN.

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 you use for production specimens. Avoid overheating the sample during surface preparation.

Certificate Number: The unique identification number for this certificate of analysis is H-13-041114. You may obtain information on revisions of certificates from the internet at 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**
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

- 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

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 April 11, 2014.

Beau R. Brammer