

Brammer Standard Company, Inc.

Certificate of Analysis

BS D-6A

Certified Reference Material for Tool Steel Grade D6 - UNS Number K24728

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values ³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.038	0.001	N	0.0031	0.0004
As	0.0101	0.0008	Ni	0.60	0.02
B	0.0004	0.0002	O	0.0009	0.0004
C	0.47	0.01	P	0.0076	0.0008
Ca	0.0011	0.0004	S	0.0010	0.0004
Co	0.013	0.001	Sb	0.0014	0.0005
Cr	0.99	0.03	Si	0.232	0.009
Cu	0.136	0.006	Ti	0.0024	0.0006
Fe	95.6	0.1	V	0.123	0.006
Mn	0.78	0.02	W	0.0019	0.0004
Mo	1.00	0.03			
	Reference Value ¹	Estimate of Uncertainty ²	Reference Values ^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
Mg	0.00014	0.00004	Sn	0.009	0.002
Nb	<0.01		Ta	0.011	0.004
Pb	0.0006	0.0004	Zr	<0.01	

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.

Trace element information values for Ce, Ga, Ge, Re, Th, U, and Zn are shown on page 4.

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

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mn					
1	5	0.0345	12	0.008833	12	0.000080	1	0.455133	12	0.00058	4	0.008	3	0.968	4	0.12625	4	95.48	3	0.742					
2	4	0.036	4	0.0093	3	0.0002	1	0.463067	14	0.0007	12	0.0100	10	0.971333	5	0.126333	16	[95.485]	4	0.744267					
3	4	0.03603333	5	0.009367	11	0.0002	1	0.463307	3	0.00090	3	0.012	4	0.9735	10	0.129667	3	95.5133333	3	0.749					
4	3	0.037	9	0.009933	3	0.0003	3	0.465	4	0.001	4	0.012	3	0.9765	10	0.13	16	[95.53]	10	0.765667					
5	5	0.03716667	5	0.009967	4	0.0003	1	0.46594	4	0.001	3	0.0121	4	0.977667	4	0.133167	16	[95.5401]	4	0.772667					
6	4	0.0372	4	0.009967	4	0.00036667	1	0.467333	3	0.00103	5	0.0121667	3	0.986	4	0.134667	16	[95.550634]	3	0.778					
7	3	0.03726667	4	0.01	7	0.00037	1	0.469667	3	0.001035	5	0.0121667	14	0.986	10	0.135	4	95.5780333	4	0.778667					
8	3	0.03775	1	0.010	3	0.000375	11	0.472	11	0.00105	3	0.0124333	4	0.99	11	0.135	14	95.6	4	0.778767					
9	4	0.0378	4	0.010167	3	0.00056	1	0.473667	3	0.0011	3	0.0126	8	0.99	4	0.135433	16	[95.6]	4	0.7793					
10	11	0.03785	3	0.0102	4	0.00056667	3	0.4765	3	0.0012	3	0.01275	4	0.99	3	0.1355	16	[95.6]	3	0.78					
11	4	0.038	4	0.010233	5	0.00076667	3	0.4765	4	0.001233	3	0.0128	4	0.990133	3	0.136	10	95.6	10	0.78					
12	8	0.038	10	0.0103			1	0.47654	4	0.0013	8	0.013	3	0.9905	4	0.136667	16	[95.64]	8	0.78					
13	10	0.038	3	0.0104			3	0.477	4	0.00149	4	0.0130667	4	0.991333	14	0.136667	16	[95.64]	4	0.78					
14	14	0.03806667	5	0.010533			1	0.479167	4	0.001867	3	0.0135	4	0.992713	3	0.137	16	[95.6567]	4	0.782233					
15	3	0.0381	3	0.0106			3	0.48			4	0.0135333	4	0.993733	3	0.137	16	[95.66]	14	0.782667					
16	4	0.03833333	3	0.0107			1	0.48			10	0.0136	3	0.995	3	0.139	4	95.684	3	0.7835					
17	3	0.0386	5	0.010767			1	0.48			4	0.0137667	11	0.9975	4	0.139733			4	0.786333					
18	3	0.03865	3	0.011			1	0.480667			4	0.0138667	3	0.999	4	0.14			3	0.788667					
19	3	0.03885					1	0.480667			4	0.014	13	1.00	4	0.140			4	0.7903					
20	4	0.0389					1	0.481			14	0.0140333	3	1.00	4	0.140167			3	0.791					
21	4	0.039533					1	0.484			4	0.014267	10	1.00	8	0.141			10	0.794					
22							1	0.485			11	0.0146	4	1.003333	3	0.142			4	0.7955					
23							1	0.486333					10	1.006					4	0.798333					
24							1	0.4973											11	0.8105					
Average		0.03784		0.010126				0.000403				0.001113		0.01272		0.989924			0.135739		95.5510		0.779640		
Std Dev		0.00096		0.000075				0.000041				0.000023		0.00044		0.000066			0.000067		0.0030		0.000065		
H		0.0020		0.0011				0.00031				0.00072		0.00044		0.011			0.0037		0.19		0.0094		
U ₁		0.0022		0.0011				0.00031				0.00078		0.00044		0.0013			0.011		0.0037		0.0094		
t-statistic		2.09		2.11				2.23				2.07		2.16		2.08			2.07		2.08		2.13		2.07
U ₂		0.0046		0.0023				0.00069				0.016		0.0010		0.0027			0.022		0.0077		0.40		0.019
U ₃		0.0010		0.00054				0.00021				0.0033		0.00026		0.00057			0.0046		0.0016		0.10		0.0040
Certified		0.038		0.0101				0.0004				0.47		0.0011		0.013			0.99		0.136		95.6		0.78
Uncertainty		0.001		0.0008				0.0002				0.01		0.0004		0.001			0.03		0.006		0.1		0.02
Tolerance		0.005		0.0024				0.0003				0.03		0.0010		0.003			0.09		0.018		0.4		0.06

Analysis	*	Mo	*	N	*	Ni	*	O	*	P	*	S	*	Sb	*	Si	*	Ti	*	V					
1	4	0.97366667	2	0.002533	3	0.575	2	0.000367	12	0.005033	1	0.0005	3	0.00105	3	0.2135	12	0.0011	3	0.117333					
2	4	0.97996667	2	0.002807	4	0.58166667	2	0.00041	5	0.0053	12	0.0006567	9	0.0011	3	0.2155	4	0.00143333	5	0.118667					
3	4	0.98	2	0.00287	4	0.58226667	2	0.000533	4	0.006433	1	0.0007667	10	0.0011	10	0.216333	5	0.00153333	4	0.119333					
4	4	0.98123333	2	0.002933	3	0.5845	2	0.0006	11	0.00695	1	0.0008167	5	0.001133	3	0.2235	5	0.00203	3	0.1195					
5	14	0.98366667	2	0.002933	4	0.58956667	2	0.000625	4	0.007167	1	0.00084	12	0.0012	4	0.226	4	0.0021	3	0.1195					
6	4	0.986	2	0.003	8	0.59	2	0.000633	4	0.0073	11	0.00085	5	0.00128	4	0.2272	5	0.00213333	4	0.119533					
7	7	0.99	2	0.003	4	0.59	2	0.0007	3	0.0074	1	0.0008933	5	0.0013	6	0.228433	3	0.0023	4	0.12					
8	3	0.99	2	0.0030	10	0.590	2	0.0008	3	0.0076	4	0.00093	9	0.0013	3	0.229	3	0.00235	3	0.12					
9	3	0.9905	2	0.003125	4	0.59006667	2	0.000873	10	0.0077	1	0.0009333	4	0.001533	4	0.2299	11	0.0026	10	0.12					
10	3	0.9945	2	0.003133	14	0.59066667	2	0.000893	3	0.007767	1	0.00094	5	0.0018	6	0.23	14	0.0027	10	0.12					
11	3	0.998	2	0.003147	3	0.591	2	0.00102	7	0.007867	1	0.0010	4	0.0019	4	0.23	4	0.0028	4	0.120133					
12	4	0.9987	2	0.0032	3	0.60	2	0.001175	4	0.007867	1	0.001	4	0.002	3	0.23	4	0.0028	4	0.1229					
13	3	1.00233333	2	0.0033	10	0.60	2	0.001733	4	0.007933	1	0.001	4	0.002	3	0.231667	3	0.0028	10	0.123					
14	4	1.01	2	0.003333	3	0.601	2	0.001767	4	0.008	1	0.0010333			3	0.233	3	0.0028	3	0.123					
15	10	1.010	2	0.0035	11	0.6035			4	0.0082	3	0.00105			14	0.233667	4	0.003	14	0.123667					
16	11	1.015			4	0.60475			3	0.0084	1	0.0012			4	0.234767	4	0.003	4	0.123667					
17	4	1.0167			10	0.607			3	0.00905	3	0.00135			10	0.235	3	0.0032	4	0.125					
18	10	1.019			4	0.60746667			3	0.0095	1	0.0013633			5	0.238			3	0.125					
19	4	1.01966667			4	0.608			3	0.00965	1	0.0014			4	0.240667			4	0.1255					
20	4	1.01986667			7	0.61					1	0.0014667			4	0.24175			11	0.1265					
21	3	1.02			3	0.6163667									11	0.243			3	0.128					
22	10	1.02			4	0.614333									4	0.2451			4	0.128667					
23					3	0.616									4	0.25133			13	0.13					
24					4	0.620667													4	0.136667					
Average		0.999945		0.00315		0.598380		0.000866		0.007638		0.001039		0.001438		0.2321			0.002393				0.1232		
Std Dev		0.000067		0.00010		0.000065		0.000085		0.000073		0.000045		0.000088		0.0028			0.000077		0.0021			0.0021	
H		0.011		0.00067		0.0081		0.00040		0.00096		0.00043		0.00049		0.0049			0.00060		0.0035			0.0035	
U ₁		0.011		0.00067		0.0081		0.00041		0.00097		0.00043		0.00050		0.0056			0.00060		0.0041			0.0041	
t-statistic		2.08		2.14		2.07		2.16		2.10		2.09		2.18		2.07			2.12		2.07				2.07
U ₂		0.022		0.0014		0.017		0.00089		0.0020		0.00091		0.0011		0.012			0.0013		0.0085			0.0085	
U ₃		0.0048		0.00037		0.0034		0.00024		0.00047		0.00020		0.00030		0.0024			0.00031		0.0017			0.0017	
Certified		1.00		0.0031		0.60		0.0009		0.0076		0.0010		0.0014		0.232			0.0024		0.123			0.123	
Uncertainty		0.03		0.0004		0.02		0.0004		0.0008		0.0004		0.0005		0.009			0.0006		0.006			0.006	
Tolerance		0.09		0.0014		0.06		0.0008		0.0024		0.0009		0.0013		0.027			0.0018		0.018			0.018	

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. 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:

$$C_L = \sqrt{S_L^2 + U_L^2} \quad W_L = \frac{1}{C_L^2} \quad A = \frac{\sum_{i=1}^n W_L M_L}{\sum_{i=1}^n W_L} \quad S = \frac{1}{\sqrt{\sum_{i=1}^n W_L}} \quad U_1 = \sqrt{H^2 + S^2} \quad U_2 = t \times U_1 \quad U_3 = \frac{U_2}{\sqrt{n}}$$

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_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 D-6A

* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ce	*	Ga	*	Ge	*	Re	*	Th	*	U	*	Zn						
1	12	0.01	12	7.9	12	12.0	12	0.3	12	0.001	12	0.003	12	0.55						
2	12	0.01	12	8.2	12	12.0	12	0.34			12	0.003	12	0.55						
3			12	8.2	12	12.0	12	0.4			12	0.004	12	0.57						

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
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Vitkovice Testing Center	Hulvaky, Ostrava	Czech Accreditation Institute	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instituto Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Shiva Analyticals Private Limited	Hoskote, Bangalore	NABL	17025
Luvak Inc.	Boylston, MA	PRI	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	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: 12X15253, 12XLA10, 12XLA90, 13XNSA8, 14X12144A, 23X80010, 23X80030; AR 115C, 165, 644, 659, 662, 668, 675, 870, 882, 884, 885, 892, 1650, 1652, 1653; BAS 8-1, 61, 72, 112, 152/2, 159/3, 258/1, 342, 345, 346A, 408/1, 409, 454, 464/1; BS CSN 2D, CSN 2-1, CSN 2-2, CSN 4, D-6, H-13, H-8, 11, 13B, 17-4PHC, 40, 43A, 45B, 46B, 56H, 73C, 75G, 80F, 88D, 179B, 179C, 183C, 187B, 625D, 1045, 2931A, 3310, 3942, 4330MOD, 4942A, 8620E, 9325A; CKD 166B, 167, 167B, 168A, 169A, 169D, 182A, 185A, 189A; SPL CZ 2025A; DSZU CA01A; ECRM 082-1, 096-1, 179-2, 184-1, 193-1, 459-1; IARM 38A, 39C, 40C, 59A, 62E, 67B, 156A, 189A, 190A; IMZ 51/1, 55/1, 55/1A; IPT 12A, 17A, 26, 31, 39, 97; JSS 168-7, 172-7, 173-5, 174-5, 175-7; KMS LCON-001; LECO 501-024, 501-504, 501-505, 501-506, 501-550, 501-644, 501-646, 501-676, 501-677, 502-195, 502-414, 502-416, 502-698, 502-712, 502-855, 502-873, 502-916, 502-928; NCS NS11028, NS11078; SRM 153, 160B, 343A, 346A, 361, 362, 363, 364, 897, 898, 899. 1162, 1262A, 1263, 2172.

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: BAS 112; BS CSN-2D, D-6, 11, 40, 43A, 3942; CKD 169S; SRM 1162, 1262A.

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 D-6A 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 Atlas Steel, Twinsburg, OH.

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 D-6A-110521. 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

Web: www.brammerstandard.com

Fax: (281) 440-4432

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 November 5, 2021.

Beau R. Brammer

President