

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 30D

Certified Reference Material for AISI T1 Tool Steel - UNS Number T12001

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0123	0.0005		Sb	0.0002
As	0.0128	0.0005		Si	0.005
C	0.745	0.004		Sn	0.0008
Ca	0.0004	0.0001		Ti	0.0007
Co	0.101	0.002		V	0.009
Cr	3.93	0.02		W	0.09
Cu	0.116	0.002			
Mn	0.348	0.004			
Mo	0.342	0.004			
N	0.0168	0.0008			
Nb	0.0071	0.0006			
Ni	0.191	0.003			
O	0.0019	0.0004			
P	0.029	0.001			
S	0.0010	0.0001			

Informational Values^{3,4}

B (0.0002)	Fe (75.0)*	Mg (0.001)	Pb (0.0002)	Ta (0.02)
Zr (0.0001)				* By Difference

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 Values in parentheses are not certified and are provided for information only.

Trace element information values for Ag, Au, Ba, Be, Bi, Br, Cd, Ce, Cl, Cs, Dy, Er, Eu, F, Ga, Gd, Ge, Hf, Hg, Ho, I, In, Ir, K, La, Li, Lu, Na, Nd, Os, Pd, Pr, Pt, Rb, Re, Rh, Ru, Sc, Se, Sm, Sr, Tb, Te, Th, Tl, Tm, U, Y, Yb, 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.

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* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Mn
1	4	0.0100	12	0.0100	1	0.733	12	0.000037	4	0.096	10	3.89	3	0.110	10	0.330
2	5	0.0100	5	0.0105	1	0.734	12	0.000089	12	0.097	4	3.91	4	0.112	4	0.333
3	5	0.0103	5	0.0120	3	0.736	4	0.00024	12	0.098	10	3.92	5	0.114	3	0.341
4	12	0.0110	12	0.0120	1	0.738	4	0.00030	10	0.099	4	3.92	4	0.114	4	0.345
5	5	0.0123	4	0.0131	1	0.740	4	0.00050	4	0.099	3	3.93	5	0.117	4	0.346
6	3	0.0131	5	0.0131	1	0.742	4	0.00059	4	0.100	4	3.94	4	0.119	4	0.351
7	4	0.0133	5	0.0132	1	0.742	4	0.00060	5	0.101	4	3.95	8	0.119	8	0.356
8	4	0.0135	9	0.0138	1	0.746	4	0.00090	3	0.104	13	3.96	4	0.119	3	0.360
9	4	0.0151	3	0.0153	1	0.747			4	0.110	4	3.98	4	0.120	5	0.364
10	4	0.0170	4	0.0155	1	0.747			8	0.111			4	0.127	12	0.365
11					1	0.751			5	0.112			4	0.129	4	0.365
12					1	0.751							12	0.130		
13					1	0.752										
14					1	0.754										
Average		0.01229		0.01277		0.7452		0.000361		0.1009		3.932		0.1162		0.3476
Std dev		0.00046		0.00052		0.0035		0.000067		0.0018		0.019		0.0015		0.0036
H		0.00055		0.00056		0.0068		0.00014		0.0018		0.025		0.0019		0.0039
U ₁		0.00072		0.00076		0.0077		0.00016		0.0025		0.032		0.0025		0.0054
t-statistic		2.26		2.26		2.16		2.36		2.23		2.31		2.20		2.23
U ₂		0.0016		0.0017		0.017		0.00038		0.0057		0.073		0.0054		0.012
U ₃		0.00052		0.00055		0.0044		0.00013		0.0017		0.024		0.0016		0.0036
Certified		0.0123		0.0128		0.745		0.0004		0.101		3.93		0.116		0.348
Uncertainty		0.0005		0.0005		0.004		0.0001		0.002		0.02		0.002		0.004
Tolerance		0.0016		0.0017		0.017		0.0004		0.006		0.07		0.005		0.012

Analysis	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	S	*	Sb
1	12	0.320	2	0.0160	12	0.0057	12	0.170	2	0.0014	4	0.0246	1	0.00020	12	0.0026
2	4	0.333	2	0.0163	5	0.0065	4	0.175	2	0.0014	3	0.0260	1	0.00050	5	0.0027
3	5	0.338	2	0.0166	3	0.0071	5	0.185	2	0.0014	4	0.0281	1	0.00050	5	0.0028
4	3	0.341	2	0.0169	5	0.0074	4	0.189	2	0.0021	7	0.0286	12	0.00085	5	0.0029
5	10	0.346	2	0.0170	5	0.0075	4	0.190	2	0.0025	4	0.0300	1	0.00090	5	0.0030
6	4	0.351	2	0.0176	5	0.0080	5	0.193			3	0.0305	1	0.00090	15	0.0032
7	5	0.354	2	0.0180	5	0.0082	3	0.196			4	0.0308	1	0.00100	5	0.0032
8	4	0.358					4	0.197			4	0.0312	1	0.00100	5	0.0035
9	4	0.361					10	0.204			5	0.0322	1	0.00100	5	0.0035
10	7	0.370					4	0.207					1	0.00149	9	0.0040
11							8	0.208					1	0.00150	12	0.0040
12													1	0.00160		
13													1	0.00170		
14													1	0.00236		
Average		0.3417		0.01675		0.00710		0.1907		0.00188		0.02950		0.001012		0.00324
Std dev		0.0040		0.00064		0.00043		0.0027		0.00020		0.00096		0.000090		0.00020
H		0.0039		0.00065		0.00043		0.0026		0.00025		0.0009		0.00020		0.00030
U ₁		0.0056		0.00091		0.00060		0.0038		0.00032		0.0013		0.00022		0.00036
t-statistic		2.26		2.45		2.45		2.23		2.78		2.31		2.16		2.23
U ₂		0.013		0.0022		0.0015		0.0085		0.00088		0.0030		0.00047		0.00081
U ₃		0.0040		0.00084		0.00056		0.0026		0.00039		0.0010		0.00013		0.00024
Certified		0.342		0.0168		0.0071		0.191		0.0019		0.029		0.0010		0.0032
Uncertainty		0.004		0.0008		0.0006		0.003		0.0004		0.001		0.0001		0.0002
Tolerance		0.013		0.0022		0.0015		0.008		0.0009		0.003		0.0005		0.0008

BS 30D * Code for method Certified values listed as weight percent

Analysis	*	Si	*	Sn	*	Ti	*	V	*	W
1	4	0.282	3	0.0233	4	0.0158	4	1.056	4	17.49
2	3	0.286	5	0.0241	4	0.0167	3	1.060	10	17.55
3	3	0.290	4	0.0242	5	0.0168	10	1.070	4	17.57
4	4	0.302	5	0.0244	5	0.0174	4	1.072	4	17.67
5	10	0.305	12	0.0245	4	0.0182	4	1.078	4	17.69
6	6	0.314	5	0.0250	4	0.0192	4	1.084	10	17.70
7	5	0.335	5	0.0250	4	0.0195	4	1.084	4	17.90
8	4	0.335	7	0.0252	10	0.0223	4	1.091	4	18.02
9			5	0.0252	12	0.0230	10	1.108	4	18.09
10			4	0.0258						
Average		0.3006		0.02461		0.01891		1.0768		17.729
Std dev		0.0042		0.00078		0.00066		0.0085		0.065
H		0.0036		0.0008		0.00069		0.009		0.09
U ₁		0.0055		0.0011		0.00095		0.012		0.11
t-statistic		2.36		2.26		2.31		2.31		2.31
U ₂		0.013		0.0025		0.0022		0.028		0.26
U ₃		0.0046		0.00079		0.00073		0.0094		0.087
Certified		0.301		0.0246		0.0189		1.077		17.73
Uncertainty		0.005		0.0008		0.0007		0.009		0.09
Tolerance		0.013		0.0025		0.0022		0.028		0.26

BS 30D * Code for method Informational values listed as weight percent

Analysis	*	B	*	Fe	*	Mg	*	Pb	*	Ta	*	Zr
1	12	0.000085	4	74.8	4	0.0002	5	0.00014	12	0.002	5	0.00008
2	4	0.00010	10	74.8	12	0.0008	5	0.00016	4	0.035	5	0.00011
3	5	0.00012	4	74.9			12	0.00016			5	0.00013
4	5	0.00020	4	75.0			5	0.00017			5	0.00014
5	7	0.00022	3	75.1			5	0.00018			12	0.00016
6	5	0.00025	4	75.2			5	0.00020			5	0.00023
7	5	0.00026	5	75.3			5	0.00020				
8							5	0.00020				
9							12	0.00024				
Average		0.000162		75.02		0.00050		0.000182		0.0181		0.000131
Std dev		0.000049		0.19		0.00016		0.000035		0.0013		0.000041
H		0.00012		0.38		0.00016		0.00012		0.0007		0.00011
U ₁		0.00013		0.42		0.00022		0.00013		0.0015		0.00012
t-statistic		2.45		2.45		12.71		2.31		12.71		2.57
U ₂		0.00031		1.03		0.0028		0.00029		0.019		0.00031
U ₃		0.00012		0.39		0.0020		0.00010		0.013		0.00013
(Certified)		(0.0002)		(75.0)		(0.001)		(0.0002)		(0.02)		(0.0001)
(Uncertainty)		(0.0001)		(0.4)		(0.002)		(0.0001)		(0.01)		(0.0001)
(Tolerance)		(0.0003)		(1.0)		(0.003)		(0.0003)		(0.02)		(0.0003)

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 uncertainty (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 times the coverage factor (95 % t-statistic). U_3 is U_2 divided by the square root of the number of determinations (n). Thus:

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

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 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 30D * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	* Ag	* Au	* Ba	* Be	* Bi	* Br	* Cd	* Ce	* Cl	* Cs
1	5 0.6	12 0.05	12 0.005	12 0.0025	5 0.2	12 0.0025	12 0.025	12 0.025	12 0.025	12 0.0025
2	12 0.72				12 0.24		5 0.05			
3	9 1.5									

Analysis	* Dy	* Er	* Eu	* F	* Ga	* Gd	* Ge	* Hf	* Hg	* Ho
1	12 0.0025	12 0.0025	12 0.0025	12 0.005	12 12	12 0.0025	5 7.2	12 0.025	12 0.025	12 0.0025
2					5 13		12 17			

Analysis	* I	* In	* Ir	* K	* La	* Li	* Lu	* Na	* Nd	* Os
1	12 0.0005	12 0.05	12 0.005	12 0.025	12 0.025	12 0.0025	12 0.0025	12 0.025	12 0.0025	12 0.025
2								12 0.17		

Analysis	* Pd	* Pr	* Pt	* Rb	* Re	* Rh	* Ru	* Sc	* Se	* Sm
1	12 0.25	12 0.0025	12 0.025	12 0.0025	12 0.42	12 0.025	12 0.05	12 0.0005	12 0.05	12 0.0025
2									5 3	

Analysis	* Sr	* Tb	* Te	* Th	* Tl	* Tm	* U	* Y	* Yb	* Zn
1	12 0.025	12 0.0025	12 0.025	12 0.0025	12 0.005	12 0.0025	12 0.0025	12 0.005	12 0.0025	12 2.8
2			5 0.05	5 0.1						5 3.4

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 | |
| 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	PRI/Nadcap	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Inco Test	Huntington, WV	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
LECO Corporation	St. Joseph, MI	BSI	9001
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
Crucible Industries LLC	Solvay, NY	SRI	9001
NSL Analytical	Cleveland, OH	PRI/Nadcap	17025
Shiva Technologies	Syracuse, NY	PRI/Nadcap	17025
VHG Labs	Manchester, NH	A2LA	17025, Guide 34

A2LA = American Association for Laboratory Accreditation

BSI = British Standards Institution

CNAS = China National Accreditation Service

Nadcap = National Aerospace and Defense Contractors Accreditation Program

PCA = Polish Center For Accreditation

PRI = Performance Review Institute

SRI = Steel Related Industries

Analysis: Chemical analyses were made on solid pieces and chips prepared by a lathe from representative samples of 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 a those listed on page 4.

Traceability: The following Certified Reference Materials were used to validate the analytical data listed on pages 2 and 3 — SRM: 50C, 132B, 337A, 361, 362, 363, 864, 1263, 2166, 3101A, 3102A, 3103A, 3107, 3109A, 3112A, 3113, 3114, 3128, 3132, 3134, 3136, 3137, 3139A, 3150, 3161A, 3162A, 3163, 3165, 3169; 501-024, 501-149, 501-501, 501-503, 501-504, 501-506, 501-550, 501+644, 501-673, 501-991, 501-992, 502-195, 502-257, 502-414; IARM: 6C, 48B; AR: 511, 669; BAS: 481/1, 482/1, 486/1; ECRM 126-1, 179-2; 14X 14944D, 14X 14945C, 14X 14952D, 14X H53K; BS: CSN 2-1, 30A, 30B, 30C.

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 — 14X 14944D, 14X 14945C, 14X 14952D; BAS: 481/1, 482/1, 486/1; BS: 30A, 30B, 30C.

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 30D 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 Crucible Industries LLC, Solvay, NY.

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 30D-110211. 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:

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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 November 02, 2011.

Beau R. Brammer