

Brammer Standard Company, Inc.

Certificate of Analysis

BS TS15

Certified Reference Material for T15 Tool Steel - T12015

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0032	0.0008		N	0.001
C	1.64	0.04		Nb	0.001
Co	4.87	0.09		S	0.005
Cr	4.12	0.06		Si	0.007
Cu	0.065	0.002		Sn	0.0009
Fe	71.4	0.2		Ti	0.0005
Mn	0.27	0.01		V	0.09
Mo	0.48	0.01		W	0.2

	Certified Value ¹	Estimate of Uncertainty ²	Reference Values^{3,4}	Certified Value ¹	Estimate of Uncertainty ²
As	0.006	0.001		O	0.002
Ni	0.18	0.02		P	0.003

Informational Values^{3,5}

B (0.0005)

Ca (0.001)

Mg (0.002)

Zr (0.003)

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 3-4 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 3-4 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.

⁵ Values in parentheses are not certified and are provided for information only.

Trace element information values for Pb is 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.

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* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N	*	Nb
1	5	0.00123	1	1.59	4	4.699866667	13	4.028	4	0.0601	3	70.946	3	0.235	3	0.447	4	0.043	12	0.00613
2	4	0.00203	1	1.596666667	14	4.71	4	4.04106667	14	0.06073	16	[70.96]	3	0.242	3	0.454	2	0.04313	4	0.007
3	3	0.0024	1	1.608666667	3	4.73	4	4.059	3	0.0629	4	71.107	14	0.24867	4	0.464	2	0.04427	4	0.00743
4	4	0.00313	1	1.613333333	4	4.734	17	4.06666667	10	0.063	13	71.207	4	0.2499	10	0.47	2	0.04443	3	0.008
5	4	0.0032	3	1.615	4	4.779	10	4.07	3	0.0633	4	71.218	4	0.25127	4	0.47003	2	0.04444	14	0.00807
6	14	0.0033	1	1.629	10	4.83	4	4.083	17	0.06333	17	71.2333	3	0.262	14	0.47067	2	0.04483	4	0.00813
7	3	0.0045	1	1.65	3	4.89	4	4.11	4	0.064	4	71.2833	8	0.264	4	0.473	2	0.04497	4	0.00823
8	4	0.006	3	1.65	4	4.915333333	4	4.11333333	4	0.0642	3	71.3133	4	0.264	3	0.481	2	0.0454	3	0.0086
9			1	1.654333333	4	4.93	4	4.13033333	4	0.06577	16	[71.333]	4	0.26867	4	0.48133	2	0.04563	5	0.0108
10			3	1.66	4	4.936033333	4	4.14	4	0.06657	16	[71.3534]	4	0.26967	10	0.483	2	0.04603	4	0.01133
11			4	1.677	4	4.953	3	4.19333333	3	0.067	14	71.8	4	0.27167	4	0.49233	2	0.0522	5	0.01143
12			1	1.6938	3	4.956666667	3	4.203	4	0.06713	16	[72.31]	4	0.277	7	0.49267			4	0.0117
13					4	4.958333333	10	4.213	8	0.06713	16	[72.6]	4	0.28333	4	0.49433				
14					10	4.993			5	0.0687			17	0.28333	4	0.49877				
15					4	4.993333333			4	0.07			3	0.28667	4	0.516				
16									4	0.0725			10	0.29						
17													10	0.290						
18													5	0.29867						
Average		0.00319		1.6424		4.9017		4.1247		0.0652		71.379		0.2629		0.4799		0.0447		0.00925
Std Dev		0.00015		0.0068		0.0066		0.0073		0.0016		0.043		0.0032		0.0045		0.0015		0.00042
H		0.00045		0.014		0.034		0.030		0.0018		0.39		0.0040		0.0060		0.0014		0.00068
U ₁		0.00047		0.016		0.035		0.031		0.0024		0.39		0.0051		0.0075		0.0021		0.00080
t-statistic		2.36		2.20		2.14		2.18		2.13		2.18		2.11		2.14		2.23		2.20
U ₂		0.0011		0.035		0.075		0.067		0.0051		0.86		0.011		0.016		0.0047		0.0018
U ₃		0.00040		0.010		0.019		0.019		0.0013		0.24		0.0026		0.0041		0.0014		0.00051
Certified		0.0032		1.64		4.87		4.12		0.065		71.4		0.27		0.48		0.045		0.009
Uncertainty		0.0008		0.04		0.09		0.06		0.002		0.2		0.01		0.01		0.001		0.001
Tolerance		0.0024		0.12		0.27		0.18		0.006		0.9		0.03		0.03		0.005		0.002

Analysis	*	S	*	Si	*	Sn	*	Ti	*	V	*	W								
1	10	0.057	5	0.321	12	0.005766667	5	0.00058667	17	4.6	3	11.07								
2	3	0.062	4	0.331533333	4	0.006533333	5	0.0007	3	4.63333	10	11.31								
3	1	0.06243	14	0.349333333	9	0.006933333	5	0.00106667	4	4.673	14	11.4								
4	1	0.06247	10	0.35	3	0.0072	3	0.0011	4	4.68867	4	11.44								
5	1	0.06257	4	0.350	4	0.007466667	4	0.00196667	4	4.72	17	11.51								
6	1	0.063	3	0.351	4	0.0078	4	0.002	4	4.72333	4	11.5667								
7	1	0.0667	6	0.354	3	0.0084	4	0.00203333	3	4.732	4	11.5684								
8	1	0.067	4	0.355666667	5	0.0085	14	0.00223333	4	4.78833	4	11.67								
9	1	0.06953	4	0.356333333	5	0.008633333	4	0.00223333	4	4.80333	4	11.7533								
10	1	0.07013	4	0.360			4	0.0025	4	4.82467	3	11.8167								
11	1	0.07073	4	0.36					4	4.9001	4	11.84								
12	4	0.073	3	0.361					14	4.92667	4	11.8543								
13			3	0.372333333					10	4.929	4	11.9033								
14			3	0.373					3	4.98	4	11.937								
15									4	4.9867										
16									3	5										
Average		0.0667		0.3574		0.00743		0.001596		4.8025		11.6693								
Std Dev		0.0019		0.0046		0.00040		0.000060		0.0066		0.0041								
H		0.00179		0.00493974		0.00062		0.00035768		0.034		0.072								
U ₁		0.0026		0.0067		0.00074		0.00036		0.034		0.072								
t-statistic		2.20		2.16		2.31		2.26		2.13		2.16								
U ₂		0.0058		0.015		0.0017		0.00082		0.073		0.16								
U ₃		0.0017		0.0039		0.00057		0.00026		0.018		0.042								
Certified		0.067		0.357		0.0074		0.0016		4.81		11.6								
Uncertainty		0.005		0.007		0.0009		0.0005		0.09		0.2								
Tolerance		0.015		0.021		0.0027		0.0015		0.27		0.6								

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* Code for method

Reference values listed as weight percent

Analysis	*	As	*	Ni	*	O	*	P
1	3	0.0043	10	0.15	2	0.0127	4	0.01186667
2	9	0.00517	3	0.15333333	2	0.015083333	12	0.01333333
3	12	0.00547	4	0.15533333	2	0.0157	5	0.01363333
4	5	0.00707	4	0.159	2	0.016366667	5	0.01453333
5	5	0.0073	17	0.16	2	0.0175	4	0.017
6	5	0.00743	4	0.16466667	2	0.018306667	3	0.018
7	5	0.00776	8	0.165	2	0.0189	4	0.0188
8			5	0.167	2	0.020233333	3	0.01883333
9			4	0.16906667	2	0.023283333	4	0.0195
10			3	0.170	2	0.023833333	10	0.020
11			4	0.19033333			4	0.02096667
12			4	0.19333333			14	0.02126667
13			3	0.219				
14			4	0.227				
15			3	0.227				
Average		0.00625		0.1847		0.01712		0.01751
Std Dev		0.00034		0.0030		0.00081		0.00081
H		0.00058		0.0032		0.0009		0.0009
U ₁		0.00067		0.0044		0.0012		0.0012
t-statistic		2.45		2.14		2.26		2.20
U ₂		0.0016		0.010		0.0027		0.0027
U ₃		0.00062		0.0025		0.00086		0.00077
Reference		0.006		0.18		0.018		0.017
Uncertainty		0.001		0.02		0.002		0.003
Tolerance		0.002		0.06		0.006		0.009

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* Code for method

Informational values listed as weight percent

Analysis	*	B	*	Ca	*	Mg	*	Zr
1	3	0.00023	12	0.0000347	12	0.00000867	5	0.00006
2	4	0.00023	3	0.00025	5	0.00001	12	0.0000603
3	4	0.0003	5	0.00246667	3	0.00021	5	0.00009
4	12	0.0005	4	0.00316667	4	0.000256667	5	0.00013
5	4	0.0006			4	0.003233333	3	0.0056
6	5	0.0006			4	0.003533333	14	0.00593333
7	5	0.0007			4	0.005333333	5	0.006
8	7	0.00083					4	0.00623333
Average		0.00050		0.0015		0.0018		0.003
Std Dev		0.00070		0.0073		0.0076		0.016
H		0.00026		0.0004		0.0004		0.000
U ₁		0.00074		0.0073		0.0076		0.016
t-statistic		2.36		3.18		2.45		2.36
U ₂		0.0018		0.023		0.019		0.038
U ₃		0.00062		0.012		0.0071		0.013
Informational		(0.0005)		(0.001)		(0.002)		(0.003)

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 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 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.

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* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Pb																		
1	12	0.0733																		

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	ACCLASS	17025
Dirats Laboratories	Westfield, MA	ACCLASS	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Exova	Santa Fe Springs, CA	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
TUVRheinland	Bangalore, India	NABL	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025

A2LA = American Association for Laboratory Accreditation
 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: 12X357, 13X12534, 13X12853, 13X43100, 28X6255; AR 646, 654, 670, 673, 875, 950, 1648, 1652, 1653; BAS 206/3, 245, 334, 335, 408, 433, 451, 459, 481/1, 483/1, 485, 486; BS A-10, A-11, H-13, H-19, HON-T, 30D, 31A, 37E, 56H, 61G, 75G, 316D, 316E, 410C, 422, 718D, 750C, 1020, 1026, 1030, 2931, 8620E; ECRM 85-1, 86-1, 87-1, 371-1D, 291-1D, 532-1; IARM 28H, 28I, 28J, 37A, 41A, 41B, 44A, 46A, 48A, 48C, 241A; IMZ 64/1, 112, 157; LECO 501-320, 501-501, 501-503, 501-504, 501-505, 501-510, 501-644, 501-646, 501-676, 501-993, 502-197, 502-257, 502-280; NCS HC37037, NS11019; SRM 11G, 15E, 50, 51B, 132A, 132B, 345, 361, 362, 363, 364, 889, 1228, 1413, 1765, 1766, 1767; Y41340b.

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 481/1, 483/1; BS A-10, H-19, HON-T, 31A, 37E; ECRM 274-1D, 291-1D, 532-1; LECO 501-676, 502-257; NCS HC37037, NS11019; SRM 364, 1765, 1767; Y41340b.

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 TS15 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 purchased from Next Generation Metals; Boca Raton, FL.

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, 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 TS15-012218. 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 9001:2008 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

- 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 17025:2005 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 35:2006 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 January 22, 2018.

Beau R. Brammer

President