

Brammer Standard Company, Inc.

Certificate of Analysis

BS TS-7A

Certified Reference Material for S-7 Tool Steel - UNS Number T41907

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.061	0.001	Mn	0.74	0.03
B	0.0021	0.0006	Mo	1.62	0.03
C	0.527	0.007	N	0.0124	0.0008
Ca	0.0004	0.0002	P	0.013	0.001
Cr	3.35	0.05	S	0.016	0.001
Cu	0.127	0.006	Si	0.84	0.04
Fe	92.3	0.2	V	0.265	0.005

	Reference Value ¹	Estimate of Uncertainty ²	Reference Values^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
As	0.005	0.003	Sb	<0.01	
Co	0.005	0.002	Sn	0.004	0.003
Mg	<0.005		Ta	<0.05	
Nb	<0.01		Ti	0.003	0.002
Ni	0.031	0.009	W	0.0014	0.0009
O	0.005	0.001	Zr	0.0015	0.0006
Pb	<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 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 Be, Bi, Ce, Cl, Ga, Ge, Ir, La, Li, Nd, Os, Re, Rh, Se, Te, Y, 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.

BS TS-7A

* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	B	*	C	*	Ca	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N
1	11	0.057167	11	0.0003	1	0.516	12	0.0000850	4	3.2706667	4	0.1183333	16	[92.18233]	4	0.7115	4	1.560667	2	0.0108667
2	10	0.058	11	0.001267	11	0.516	11	0.0002667	11	3.2866667	4	0.1185	16	[92.23]	10	0.716	4	1.596	2	0.0118067
3	4	0.0598	11	0.0017	1	0.51766667	3	0.0003	11	3.2866667	3	0.1206667	16	[92.3]	3	0.722333	4	1.597467	2	0.0121
4	11	0.06	4	0.001867	3	0.52	3	0.0003	3	3.32	3	0.123	16	[92.34]	5	0.725	4	1.5993	2	0.0122667
5	3	0.060	5	0.00198	3	0.52266667	3	0.0003	4	3.3280333	4	0.1233333	3	92.34333333	4	0.728333	3	1.60	2	0.0122667
6	14	0.060133	3	0.0020	1	0.52366667	11	0.0003333	4	3.346	3	0.125	4	92.34403333	4	0.728667	14	1.60	2	0.01235
7	3	0.060167	3	0.002067	11	0.524	11	0.0004	14	3.35	3	0.125	4	92.35333333	3	0.73	4	1.600133	2	0.0124
8	3	0.060467	12	0.0022	11	0.52466667	4	0.00041	10	3.35	4	0.1253333	10	92.36	3	0.733	3	1.601	2	0.0124
9	4	0.0605	4	0.0022	1	0.52466667	3	0.0005667	3	3.350	3	0.126	13	92.39366667	3	0.735667	4	1.603833	2	0.0124333
10	4	0.060533	7	0.002223	1	0.52466667	4	0.0007	4	3.3503333	4	0.1279667	16	[92.3966]	4	0.7371	4	1.607667	2	0.0124667
11	4	0.060567	4	0.002633	3	0.525			4	3.3519	10	0.128	14	92.4	11	0.738	4	1.61	2	0.0129
12	3	0.0606	3	0.0027	1	0.52553333			4	3.3566667	11	0.128	16	[92.400567]	4	0.739	7	1.61	2	0.0130
13	4	0.0614	5	0.002733	1	0.52566667			11	3.36	14	0.1286667	16	[92.44]	3	0.739	11	1.64	2	0.0133333
14	11	0.0616	3	0.0041	1	0.52613333			13	3.36	5	0.1286667	16	[92.44]	14	0.739333	11	1.643333		
15	4	0.0617			1	0.52733333			8	3.36	4	0.1288	16	[92.45]	10	0.74	3	1.646667		
16	3	0.062			1	0.52855			4	3.3603667	4	0.1298333	16	[92.46]	8	0.74	4	1.6475		
17	3	0.0626			1	0.53033333			3	3.37	4	0.1301	16	[92.5334]	4	0.742433	10	1.65		
18	4	0.062933			1	0.53366667			10	3.37	11	0.1303333			11	0.742667	4	1.652		
19	5	0.0634			1	0.541			4	3.3733333	10	0.131			4	0.7456	3	1.653333		
20					1	0.543			4	3.38	4	0.131			11	0.747	10	1.673333		
21									3	3.38	3	0.131667			4	0.747333	11	1.69		
22									3	3.38	11	0.132333			4	0.753				
23									3	3.39					3	0.76				
24									4	3.397667										
Average		0.0608		0.002141		0.5270		0.000401		3.3593		0.126888		92.334		0.736564		1.6226		0.01240
Std Dev		0.0014		0.000085		0.0033		0.000013		0.0055		0.000067		0.024		0.000066		0.0056		0.00041
H		0.0025		0.00057		0.0076		0.00031		0.022		0.0036		0.18		0.0091		0.014		0.0012
U ₁		0.0029		0.00058		0.0083		0.00031		0.023		0.0036		0.18		0.0091		0.015		0.0013
t-statistic		2.10		2.16		2.09		2.26		2.07		2.08		2.12		2.07		2.09		2.18
U ₂		0.0060		0.0012		0.017		0.00069		0.047		0.0075		0.39		0.019		0.032		0.0027
U ₃		0.0014		0.00033		0.0039		0.00022		0.010		0.0016		0.10		0.0039		0.0070		0.00076
Certified		0.061		0.0021		0.527		0.0004		3.35		0.127		92.3		0.74		1.62		0.0124
Uncertainty		0.001		0.0006		0.007		0.0002		0.05		0.006		0.2		0.03		0.03		0.0008
Tolerance		0.006		0.0018		0.021		0.0003		0.15		0.018		0.6		0.09		0.09		0.0027

Analysis	*	P	*	S	*	Si	*	V												
1	4	0.009	3	0.0139	3	0.78766667	3	0.2406667												
2	1	0.0097	1	0.014	4	0.8155	10	0.242												
3	11	0.012	1	0.0146	11	0.817	4	0.2455												
4	4	0.012133	1	0.014653	4	0.82266667	11	0.2626667												
5	4	0.0122	3	0.0149	11	0.82266667	4	0.2636667												
6	5	0.012233	1	0.0151	4	0.823	11	0.264												
7	11	0.012333	3	0.0152	4	0.832	4	0.2643333												
8	4	0.012667	1	0.015267	4	0.83316667	3	0.2646667												
9	7	0.012667	1	0.0154	11	0.839	10	0.265												
10	10	0.0128	11	0.0155	14	0.83966667	11	0.2656667												
11	11	0.0128	1	0.015567	4	0.83966667	4	0.2664333												
12	4	0.0132	1	0.015625	6	0.8398	4	0.267												
13	14	0.013367	1	0.0158	6	0.84	3	0.2673333												
14	4	0.013367	1	0.016	17	0.84063333	4	0.2685333												
15	3	0.013667	11	0.016	3	0.842	3	0.269												
16	3	0.0139	11	0.016	4	0.84333333	4	0.2690667												
17	3	0.014	10	0.0162	3	0.845	3	0.27												
18	3	0.014167	1	0.016433	3	0.84633333	3	0.27												
19	3	0.014267	1	0.0165	3	0.848	13	0.27												
20	3	0.0144	1	0.0168	10	0.85	4	0.2702333												
21	10	0.014567	3	0.017	3	0.877	14	0.270333												
22	4	0.0153	1	0.0172			4	0.279667												
23			1	0.017367			5	0.288667												
Average		0.01304		0.01579		0.835433		0.265410												
Std Dev		0.00041		0.00042		0.000069		0.000066												
H		0.0012		0.0013		0.0098		0.0052												
U ₁		0.0013		0.0014		0.0098		0.0052												
t-statistic		2.08		2.07		2.09		2.07												
U ₂		0.0027		0.0029		0.020		0.011												
U ₃		0.00057		0.00060		0.0045		0.0023												
Certified		0.013		0.016		0.84		0.265												
Uncertainty		0.001		0.001		0.04		0.005												
Tolerance		0.003		0.003		0.12		0.015												

BS TS-7A * Code for method Reference values listed as weight percent

Analysis	*	As	*	Co	*	Mg	*	Nb	*	Ni	*	O	*	Pb	*	Sb	*	Sn	*	Ta
1	12	0.002333	3	0.003	3	0.0000403	5	0.0001433	4	0.022	2	0.004	3	0.00000428	12	0.000653	12	0.00073	3	0.0007
2	5	0.002527	14	0.003033	12	0.000069	12	0.0001767	14	0.0222667	2	0.0042833	12	0.00014	5	0.0007	5	0.001267	10	0.0012
3	5	0.0026	12	0.003533	3	0.0001	4	0.0010333	4	0.0224667	2	0.0043333	5	0.000146667	5	0.000703	5	0.001267	4	0.005
4	5	0.0026	5	0.003867	3	0.0001	11	0.0015	12	0.0240	2	0.0044333	5	0.000156667	5	0.000743	5	0.0014	4	0.0068667
5	3	0.0029	3	0.0039	4	0.00016667	11	0.0028	4	0.0258	2	0.0047	5	0.0002	3	0.000867	5	0.00141	4	0.0129333
6	10	0.0036	4	0.004	11	0.0003	3	0.0029667	4	0.0283333	2	0.0050333	9	0.0003	3	0.0023	4	0.0022		
7	11	0.0052	5	0.0043	4	0.00032333	14	0.0041	4	0.0301667	2	0.00517	3	0.0005	9	0.002633	10	0.0025		
8	3	0.0053	5	0.004393			3	0.005	4	0.0306	2	0.0052333	10	0.0008	11	0.0033	3	0.0030		
9	9	0.005567	4	0.0047			11	0.006	3	0.0320667	2	0.0053	3	0.000866667	4	0.003567	3	0.0032		
10	4	0.005767	4	0.0048			3	0.0084	3	0.033	2	0.00545			4	0.004033	3	0.003733		
11	4	0.006433	10	0.0049			3	0.0088	5	0.0335333	2	0.0062333			3	0.0054	3	0.004		
12	3	0.007733	3	0.0052					11	0.0342	2	0.0068			11	0.0056	3	0.0063		
13	3	0.007833	3	0.0071					4	0.0343							4	0.0064		
14			11	0.0098					3	0.0345667							11	0.0067		
15			3	0.0098					8	0.035							4	0.006933		
16									3	0.0353							9	0.007233		
17									4	0.0358667							4	0.007767		
18									10	0.036										
19									10	0.0363333										
20									3	0.037										
Average		0.004646		0.005088		0.0002993		0.003720		0.031140		0.005081		0.000153		0.002646		0.003885		0.00631
Std Dev		0.000088		0.000082		0.0000013		0.000095		0.000071		0.000091		0.000047		0.000079		0.000077		0.00027
H		0.00078		0.00081		0.00028		0.00071		0.0018		0.00081		0.00022		0.00062		0.00073		0.00089
U ₁		0.00079		0.00081		0.00028		0.00072		0.0018		0.00082		0.00023		0.00063		0.00073		0.00093
t-statistic		2.18		2.14		2.45		2.23		2.09		2.20		2.31		2.20		2.12		2.78
U ₂		0.0017		0.0017		0.00068		0.0016		0.0038		0.0018		0.00052		0.0014		0.0015		0.0026
U ₃		0.00047		0.00045		0.00026		0.00048		0.00085		0.00052		0.00017		0.00040		0.00037		0.0012
Reference		0.005		0.005		<0.005		<0.01		0.031		0.005		<0.001		<0.01		0.004		<0.05
Uncertainty		0.003		0.002						0.009		0.001						0.003		
Tolerance		0.004		0.004						0.027		0.003						0.003		

Analysis	*	Ti	*	W	*	Zr															
1	11	0.0007	12	0.000467	5	0.0000933															
2	12	0.00092	5	0.000533	12	0.00012333															
3	5	0.00146	5	0.000787	4	0.001															
4	5	0.001533	3	0.001667	3	0.001															
5	5	0.0016	3	0.0017	3	0.0016															
6	3	0.002	4	0.002067	3	0.0018															
7	4	0.002667	4	0.002833	4	0.0019															
8	4	0.0028			4	0.00193333															
9	4	0.0029			10	0.0021															
10	3	0.0029			3	0.00246667															
11	4	0.002933			11	0.003															
12	3	0.0031																			
13	14	0.003167																			
14	3	0.003267																			
15	11	0.004																			
16	11	0.0045																			
17	3	0.004733																			
Average		0.002658		0.00144		0.001547															
Std Dev		0.000077		0.00012		0.000095															
H		0.00062		0.00049		0.00050															
U ₁		0.00063		0.00050		0.00051															
t-statistic		2.12		2.45		2.23															
U ₂		0.0013		0.0012		0.0011															
U ₃		0.00032		0.00047		0.00034															
Reference		0.003		0.0014		0.0015															
Uncertainty		0.002		0.0009		0.0006															
Tolerance		0.002		0.0013		0.0014															

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 TS-7A

* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Be	*	Bi	*	Ce	*	Cl	*	Ga	*	Ge	*	Ir	*	La	*	Li	*	Nd
1	12	0.005	12	0.33	12	0.04	12	0.01	12	6.1	12	5.4	12	0.02	12	0.02	12	0.005	12	0.01
2	12	0.005	12	0.34	12	0.04			12	6.2	12	5.5	12	0.02	12	0.02	12	0.005	12	0.01
3			12	0.36	12	0.05			12	6.3	12	5.6	12	0.02	12	0.02	12	0.005	12	0.02
Analysis	*	Os	*	Re	*	Rh	*	Se	*	Te	*	Y	*	Zn						
1	12	0.02	12	1.0	12	0.76	12	1.0	12	0.25	12	0.01	12	6.6						
2	12	0.02	12	1.0	12	0.78	12	1.1	12	0.26	12	0.01	12	6.7						
3	12	0.02	12	1.1	12	0.79	12	1.1	12	0.26	12	0.01	12	6.8						

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 | 17 | Wet |
| 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
LECO Corporation	St. Joseph, MI	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Vitkovice Testing Center	Ostrava, Czech Republic	Czech Accreditation Institute	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Luvak Inc.	Boylston, MA	PRI	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Shiva Analyticals	Hoskote, Bangalore	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: 12X40CDV12A, 12XLA90, 23X80030; AR 614A, 644, 645, 654, 657, 659, 668, 673, 873, 874, 876, 882, 892, 960; BAS 149/3, 161/3, 224, 251/1, 257/1, 273, 407, 431, 434, 461/1, 464/1, 613/1; BS A-10, CE 031, CSN 2-2, CSN 2D, H-13, H-13A, M-50, TH-12, TS-7, XCCS-1, 46B, 49, 56H, 73C, 74E, 1009, 1018, 1045, 2931A, 8620A; CKD 170A, 170H, 171, 181A, 187A, 188A; DSZU CA01A; ECRM 082-1, 276-2D; IARM 30C, 259A; IMZ 53/1, 110, 112, 114A, 135, 137, 172, 173; JSM M402-4; JSS 168-7, 169-5, 170-7; LECO 501-644, 501-677, 502-364, 502-414, 502-698, 502-704, 502-893, 502-904, 502-916, 502-935, 502-977, 502-989, 502-990; NCS NS21006; SPL 187A, 188A; SRM 13F, 72G, 139B, 153, 160B, 361, 363, 1099, 1139A, 1167, 1228, 1755, 1766, 1767, 1772; SUS Fe D/1; Y 31901.

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 613/1; BS TH-12, 46B, 49; CKD 170H; ECRM 276-2D; SRM 1139A, 1772; SUS Fe D/1.

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 TS-7A 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 cast stock for this CRM was produced by SPL-LABMAT s.r.o.; Bohumin, Czech Republic.

Form: This CRM is machined in the form of a disc, approximately 36mm in diameter and 25mm 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 certified area of each disc is the portion extending several mm inward from each surface.

Note: Shrinkage cavities may appear in the horizontal center of some discs.

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 TS-7A-092321. 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 September 23, 2021.

Beau R. Brammer

President