

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS A-11

Certified Reference Material for Tool Steel Grade A-11 - UNS Number T30111

	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	<b>Certified Values<sup>3</sup></b>	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	
<b>Al</b>	<b>0.0054</b>	0.0005		<b>Si</b>	<b>0.98</b>	0.04
<b>As</b>	<b>0.0057</b>	0.0005		<b>Sn</b>	<b>0.0055</b>	0.0004
<b>B</b>	<b>0.0008</b>	0.0002		<b>Ti</b>	<b>0.0019</b>	0.0005
<b>C</b>	<b>2.42</b>	0.01		<b>V</b>	<b>9.24</b>	0.04
<b>Co</b>	<b>0.044</b>	0.001				
<b>Cr</b>	<b>5.21</b>	0.09				
<b>Cu</b>	<b>0.092</b>	0.002				
<b>Fe</b>	<b>79.5</b>	0.3				
<b>Mn</b>	<b>0.507</b>	0.005				
<b>Mo</b>	<b>1.25</b>	0.03				
<b>N</b>	<b>0.110</b>	0.004				
<b>Ni</b>	<b>0.25</b>	0.01				
<b>O</b>	<b>0.028</b>	0.001				
<b>P</b>	<b>0.023</b>	0.001				
<b>S</b>	<b>0.123</b>	0.005				

#### Informational Values<sup>3,4</sup>

Ca (0.0002)	Mg (0.0005)	Nb (0.0070)	Pb (0.00006)	Sb (0.001)
W (0.080)	Zr (0.001)			

<sup>1</sup> 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.

<sup>2</sup> 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.

<sup>3</sup> Values are given in weight percent. Values in brackets are reported by difference.

<sup>4</sup> Values in parentheses are not certified and are provided for information only.

Trace element information values for Bi, Cl, Ga, Ge, K, Na, Re, Ta, 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.

**BS A-11** \* Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe
1	5	0.003933	5	0.0040	4	0.000567	1	2.356667	3	0.035033	4	5.073333	5	0.088167	10	79.27667
2	12	0.0045	5	0.004733	7	0.000767	3	2.3575	4	0.038667	3	5.093333	4	0.088267	3	79.34
3	4	0.005533	15	0.005013	4	0.0008	1	2.403333	3	0.03875	10	5.106667	3	0.088525	13	79.38633
4	3	0.0056	5	0.005767	5	0.0008	1	2.405	12	0.0430	4	5.130	14	0.0895	14	79.4
5	4	0.0059	3	0.0058	12	0.00093	1	2.41	4	0.043267	13	5.170667	4	0.089933	4	79.45
6	14	0.005967	5	0.005833	3	0.000995	1	2.413333	14	0.044067	10	5.216667	3	0.090133	16	[79.48833]
7	5	0.006167	9	0.006233	4	0.0010	1	2.415	8	0.0441	4	5.219333	4	0.090167	16	[79.54667]
8	4	0.0074	12	0.0070	5	0.001	1	2.419767	5	0.044167	4	5.2373	4	0.090867	16	[79.58667]
9			4	0.0074	14	0.001467	1	2.428	5	0.044233	3	5.27	4	0.091333	16	[79.64]
10							1	2.443333	10	0.045	4	5.28	10	0.092	10	79.69667
11							1	2.453333	4	0.045	10	5.29	4	0.092	16	[79.82333]
12							1	2.483333	4	0.045133	14	5.306667	5	0.092533		
13									4	0.046333	4	5.318	8	0.093667		
14									10	0.047667	4	5.398	10	0.093833		
15									4	0.048167			12	0.0970		
16													10	0.099333		
Average		0.00540		0.00570		0.000765		2.4172		0.0444		5.2129		0.0917		79.531
Std dev		0.00033		0.00028		0.000048		0.0061		0.0014		0.0062		0.0024		0.048
H		0.00055		0.00056		0.00029		0.019		0.0014		0.036		0.0021		0.44
U <sub>1</sub>		0.00064		0.00062		0.00030		0.020		0.0020		0.036		0.0032		0.44
t-statistic		2.36		2.31		2.31		2.20		2.14		2.16		2.13		2.23
U <sub>2</sub>		0.0015		0.0014		0.00068		0.044		0.0043		0.078		0.0068		0.99
U <sub>3</sub>		0.00053		0.00048		0.00023		0.013		0.0011		0.021		0.0017		0.30
<b>Certified</b>		<b>0.0054</b>		<b>0.0057</b>		<b>0.0008</b>		<b>2.42</b>		<b>0.044</b>		<b>5.21</b>		<b>0.092</b>		<b>79.5</b>
<b>Uncertainty</b>		<b>0.0005</b>		<b>0.0005</b>		<b>0.0002</b>		<b>0.01</b>		<b>0.001</b>		<b>0.09</b>		<b>0.002</b>		<b>0.3</b>
Tolerance		0.0015		0.0014		0.0007		0.04		0.004		0.16		0.007		1.0

Analysis	*	Mn	*	Mo	*	N	*	Ni	*	O	*	P	*	S	*	Si
1	4	0.492	4	1.206667	2	0.1032	3	0.234667	2	0.027367	4	0.018333	3	0.11475	4	0.94
2	3	0.494667	4	1.214333	2	0.103333	10	0.244333	2	0.027367	7	0.020067	12	0.1150	4	0.966933
3	3	0.495	4	1.223333	2	0.104967	4	0.247	2	0.0275	5	0.0203	1	0.116667	4	0.980
4	4	0.499333	14	1.236667	2	0.106833	4	0.247	2	0.027833	5	0.021167	1	0.117	14	0.981333
5	4	0.502	7	1.247333	2	0.107667	5	0.247667	2	0.028025	4	0.021567	1	0.118433	3	0.982
6	14	0.502	4	1.25	2	0.108	4	0.248967	2	0.028617	14	0.021967	1	0.12	4	0.996333
7	10	0.502667	10	1.266667	2	0.1112	8	0.25	2	0.0288	4	0.022467	1	0.123	4	1.002067
8	4	0.503333	3	1.2675	2	0.112	10	0.250	2	0.02912	4	0.022667	10	0.124	3	1.003333
9	8	0.507	4	1.276667	2	0.113	4	0.256333	2	0.0296	4	0.023267	1	0.124	6	1.009
10	4	0.510	4	1.277733	2	0.113725	4	0.263133	2	0.03015	3	0.023567	1	0.124	4	1.02
11	4	0.513133	10	1.28	2	0.114	4	0.263333	2	0.031167	12	0.0240	1	0.125333	6	1.03
12	10	0.519	3	1.28			10	0.274			10	0.025	1	0.135167	4	1.038333
13	4	0.536	4	1.2875			4	0.274			4	0.025167	1	0.137333	10	1.04
14	10	0.536667	10	1.33			14	0.278333			10	0.0257	1	0.139333	10	1.056667
15											3	0.02765			10	1.06
Average		0.5067		1.2523		0.1098		0.2580		0.0285		0.0229		0.1234		0.9793
Std dev		0.0058		0.0068		0.0028		0.0042		0.0010		0.0010		0.0028		0.0066
H		0.0061		0.012		0.0023		0.0039		0.0011		0.0010		0.0025		0.010
U <sub>1</sub>		0.0085		0.013		0.0036		0.0057		0.0015		0.0014		0.0037		0.012
t-statistic		2.16		2.16		2.23		2.16		2.23		2.14		2.16		2.14
U <sub>2</sub>		0.018		0.029		0.0081		0.012		0.0034		0.0031		0.0081		0.025
U <sub>3</sub>		0.0049		0.0080		0.0024		0.0030		0.0010		0.00080		0.0022		0.0070
<b>Certified</b>		<b>0.507</b>		<b>1.25</b>		<b>0.110</b>		<b>0.25</b>		<b>0.028</b>		<b>0.023</b>		<b>0.123</b>		<b>0.98</b>
<b>Uncertainty</b>		<b>0.005</b>		<b>0.03</b>		<b>0.004</b>		<b>0.01</b>		<b>0.001</b>		<b>0.001</b>		<b>0.005</b>		<b>0.04</b>
Tolerance		0.018		0.06		0.008		0.03		0.003		0.003		0.015		0.08

**BS A-11** \* Code for method Certified values listed as weight percent

Analysis	*	Sn	*	Ti	*	V
1	12	0.0039	4	0.0015	4	9.206667
2	5	0.0047	5	0.0018	3	9.2125
3	5	0.0051	5	0.001833	4	9.243
4	5	0.0051	12	0.0020	13	9.250667
5	3	0.00515	4	0.002867	4	9.263
6	5	0.0053			10	9.263333
7	4	0.005333			10	9.27
8	4	0.0055			14	9.27
9	5	0.00555			4	9.279667
10	9	0.006267			4	9.346667
11					4	9.37
12					4	9.4027
13					10	9.553333
Average		0.00546		0.00192		9.2440
Std dev		0.00022		0.00018		0.0045
H		0.00055		0.00038		0.058
U <sub>1</sub>		0.00059		0.00042		0.058
t-statistic		2.26		2.78		2.18
U <sub>2</sub>		0.0013		0.0012		0.13
U <sub>3</sub>		0.00042		0.00052		0.035
<b>Certified</b>		<b>0.0055</b>		<b>0.0019</b>		<b>9.24</b>
<b>Uncertainty</b>		<b>0.0004</b>		<b>0.0005</b>		<b>0.04</b>
<b>Tolerance</b>		0.0013		0.0012		0.13

**BS A-11** \* Code for method Informational values listed as weight percent

Analysis	*	Ca	*	Mg	*	Nb	*	Pb	*	Sb	*	W	*	Zr
1	12	0.000030	12	0.000021	4	0.0030667	5	0.000057	4	0.0011	10	0.059333	4	0.0001
2	3	0.00007	5	0.000035	5	0.0052	12	0.000065	5	0.0012	3	0.061925	5	0.000167
3	4	0.0002	3	0.00008	5	0.005203			12	0.0018	4	0.064667	5	0.0002
4	4	0.000433	4	0.0002	5	0.005233					14	0.0649	12	0.00070
5			4	0.002167	5	0.006067					12	0.0700	10	0.0011
6					12	0.0066					4	0.073667	3	0.0011
7					4	0.008167					3	0.082767	5	0.0012
8					10	0.0095					4	0.087467	4	0.003633
9					4	0.009667					7	0.0899		
10					3	0.0114					4	0.090233		
11					14	0.011633					4	0.0911		
12											5	0.092967		
13											5	0.0940		
14											10	0.099667		
15											4	0.1062		
Average		0.00018		0.00050		0.007		0.000061		0.0014		0.08		0.0010
Std dev		0.00011		0.00091		0.054		0.000010		0.0079		0.43		0.0029
H		0.00022		0.00026		0.001		0.00019		0.0003		0.00		0.0003
U <sub>1</sub>		0.00024		0.00094		0.054		0.00019		0.0079		0.43		0.0029
t-statistic		3.18		2.78		2.23		12.71		4.30		2.14		2.36
U <sub>2</sub>		0.00078		0.0026		0.12		0.0024		0.034		0.93		0.0068
U <sub>3</sub>		0.00039		0.0012		0.036		0.0017		0.020		0.240		0.0024
<b>(Informational)</b>		<b>(0.0002)</b>		<b>(0.0005)</b>		<b>(0.0070)</b>		<b>(0.00006)</b>		<b>(0.001)</b>		<b>(0.080)</b>		<b>(0.001)</b>

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.  $U_1$  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 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 *	Bi	CI	Ga	Ge	K	Na	Re	Ta	Zn
1	12 0.037	12 0.028	5 21	5 23	12 0.32	12 0.63	12 0.93	12 0.50	12 1.8
2			5 21	5 24			5 6.9		
3			12 22	5 24			5 6.9		
4			5 23	12 24			5 7.0		
5									
6									
7									
8									
9									
10									

#### 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

<u>Laboratory</u>	<u>Location</u>	<u>Registrar</u>	<u>Accreditation</u>
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
LECO Corporation	St. Joseph, MI	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Dirats Laboratories	Westfield, MA	ACCLASS	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Exova	Glendale Heights, IL	A2LA	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025

A2LA = American Association for Laboratory Accreditation  
ACCLASS = ANSI-ASQ National Accreditation Board  
CNAS = China National Accreditation Service  
Nadcap = National Aerospace and Defense Contractors Accreditation Program  
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: 13X21800, 18XD7; 501-024, 501-105, 501-320, 501-501, 501-504, 501-506, 501-644, 501-646, 501-675, 501-676, 501-677, 501-993, 501-994, 502-016, 502-072, 502-231, 502-257, 502-280, 502-873, 502-875; AR 644, 659, 670, 673, 875, 889, 896, 961, 1647, 1652, 1656; BAS 220/2, 345, 403, 464/1, 486; BS A-10, H13, HON-T, PM15, 30D, 34C, 36D, 56H, 1030, 8620C; CKD 215, 244; CZ 2017A; ECRM 85, 87, 274-1D, 283-1, 489-1; IARM 42A, 42B, 42C; IMZ 112; KMS HOCS-001; NCS NS11028, NS11037; SRM 36A, 101D, 101E, 132, 153A, 160B, 346A, 348, 361, 363, 866, 1246, 1249, 1263A, 1264A, 1413, 1763A.

**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 — 501-676; BS A-10, PM15, HON-T, 34C; CKD 215, 244; ECRM 274-1D, 283-1; KMS HOCS-001; NCS NS11028, NS11037; SRM 346A.

**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 A-11 is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

**Source:** The bar stock for this CRM was provided by 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 A-11-011216. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://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.**                      **Phone: (281) 440-9396**    **Web: [www.brammerstandard.com](http://www.brammerstandard.com)**  
**14603 Benfer Road**  
**Houston, Texas 77069-2895 USA**              **Fax: (281) 440-4432**              **Email: [contact@brammerstandard.com](mailto: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](http://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 9001:2008    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](http://www.global.ihs.com)*

*Other useful documents available from NIST, U.S. Department of Commerce, Gaithersburg, MD 20899.*

**Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895**  
**Telephone: (281) 440-9396    Fax: (281) 440-4432    Website: [www.brammerstandard.com](http://www.brammerstandard.com)**  
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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 12, 2016.

Beau R. Brammer