

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 46B

Certified Reference Material for ASTM A182 Grade F22 - UNS Number K21590

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.020	0.001		Si	0.003
As	0.0041	0.0003		Sn	0.0004
C	0.126	0.005		V	0.0009
Ca	0.0009	0.0003		W	0.0002
Co	0.0074	0.0004			
Cr	2.28	0.01			
Cu	0.128	0.002			
Fe	95.7	0.3			
Mn	0.472	0.004			
Mo	1.00	0.01			
N	0.0100	0.0006			
Ni	0.081	0.002			
O	0.0026	0.0003			
P	0.0087	0.0006			
S	0.0187	0.0008			

Informational Values^{3,4}

B (0.0006)	Mg (0.0003)	Nb (0.003)	Pb (0.001)	Sb (0.002)
Ti (0.001)	Zr (0.002)			

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

Trace element information values for Bi, Ga, Ge, Re, 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.

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* Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe
1	3	0.018467	4	0.002533	1	0.116333	3	0.00049	3	0.0056	4	2.2	10	0.120667	13	95.530
2	4	0.018733	4	0.0031	1	0.1174	14	0.0007	5	0.006633	3	2.222013	5	0.121333	16	[95.56]
3	4	0.018867	9	0.003267	1	0.119767	4	0.000997	4	0.0068	17	2.2522	5	0.1220	3	95.56667
4	4	0.019067	5	0.003867	1	0.121	4	0.001123	14	0.007167	4	2.258667	10	0.124	16	[95.58]
5	5	0.019333	3	0.0039	1	0.1215	4	0.0013	5	0.007233	4	2.27	3	0.125	14	95.6
6	12	0.0195	5	0.003967	1	0.122333	12	0.001383	8	0.00737	13	2.27	4	0.126333	10	95.61
7	5	0.019867	12	0.004033	1	0.125			5	0.007433	3	2.27	4	0.126667	16	[95.62]
8	14	0.019933	15	0.004183	1	0.125			5	0.0076	4	2.273	3	0.127	16	[95.62333]
9	4	0.02	10	0.0043	1	0.126367			3	0.0076	4	2.283	4	0.127367	4	95.65
10	4	0.0205	3	0.0048	1	0.129733			5	0.007627	10	2.285	4	0.128333	4	95.67537
11	3	0.0212	5	0.0051	3	0.1329937			4	0.007633	3	2.286667	3	0.12900	4	96.0
12	3	0.0227	5	0.005267	3	0.13			4	0.007733	3	2.29	14	0.129333	10	96.028
13	4	0.022733	4	0.0059	3	0.131			12	0.007967	3	2.29	4	0.129333		
14	3	0.023			3	0.131			10	0.0085	10	2.293333	8	0.129667		
15									3	0.00888	4	2.3000	3	0.13		
16									3	0.009	14	2.30	4	0.130		
17											4	2.309667	4	0.130233		
18													3	0.132		
Average		0.02020		0.00407		0.1256		0.000924		0.00740		2.2838		0.1283		95.658
Std dev		0.00057		0.00017		0.0027		0.000090		0.00029		0.0049		0.0026		0.033
H		0.0010		0.00050		0.0026		0.00031		0.00063		0.019		0.0026		0.50
U ₁		0.0011		0.00053		0.0037		0.00032		0.00070		0.019		0.0037		0.50
t-statistic		2.16		2.18		2.16		2.57		2.13		2.12		2.11		2.20
U ₂		0.0025		0.0012		0.0081		0.00082		0.0015		0.041		0.0078		1.11
U ₃		0.00070		0.00032		0.0022		0.00033		0.00037		0.010		0.0018		0.32
Certified		0.020		0.0041		0.126		0.0009		0.0074		2.28		0.128		95.7
Uncertainty		0.001		0.0003		0.005		0.0003		0.0004		0.01		0.002		0.3
Tolerance		0.002		0.0012		0.015		0.0008		0.0015		0.04		0.008		1.1

Analysis	*	Mn	*	Mo	*	N	*	Ni	*	O	*	P	*	S	*	Si
1	10	0.465	4	0.9531	2	0.0080	5	0.068667	2	0.0014	3	0.0059	1	0.016025	4	0.195333
2	10	0.465	4	0.960667	2	0.008567	4	0.0727	2	0.001677	5	0.006967	12	0.016167	6	0.195667
3	10	0.466	4	0.969333	2	0.009667	4	0.0755	2	0.0018	7	0.007323	1	0.016533	10	0.204333
4	4	0.466367	4	0.986667	2	0.009737	8	0.0773	2	0.001953	10	0.0079	1	0.0176	4	0.209333
5	8	0.469	3	0.99	2	0.0098	3	0.0788	2	0.002333	12	0.008133	1	0.017867	3	0.217
6	4	0.469	10	0.996	2	0.010367	4	0.0790	2	0.002567	4	0.0082	1	0.018333	14	0.218667
7	14	0.469	10	0.998	2	0.0105	3	0.079567	2	0.002583	10	0.008367	3	0.0186	4	0.219
8	3	0.47	7	0.998	2	0.0105	4	0.079967	2	0.0026	4	0.008533	3	0.019	4	0.219167
9	3	0.47	4	0.999867	2	0.01078	10	0.08	2	0.002667	4	0.00865	1	0.0191	4	0.2193
10	4	0.471	3	1.0	2	0.011467	5	0.0803	2	0.003033	4	0.008767	1	0.019333	4	0.222
11	4	0.472333	4	1.0016			14	0.080733	2	0.003193	3	0.00891	1	0.019333	3	0.223
12	4	0.473667	14	1.003333			3	0.080757			5	0.00967	1	0.019367	6	0.223333
13	4	0.475	3	1.005267			10	0.080867			4	0.0090	3	0.0194	5	0.225133
14	3	0.478	10	1.01			3	0.083			14	0.009033	1	0.0195	3	0.22538
15	4	0.483433	3	1.01			4	0.083433			7	0.0096	3	0.01961	3	0.23
16	4	0.484333	3	1.01			10	0.084			5	0.009933	1	0.019833	10	0.23
17	3	0.48439	4	1.017			4	0.085267			3	0.010	3	0.021333	3	0.231333
18			4	1.033			12	0.0870			3	0.010733	4	0.236667		
19			4	1.036667			3	0.0884			3	0.011	4	0.237		
Average		0.4723		0.998		0.00997		0.0808		0.002632		0.00871		0.01866		0.2188
Std dev		0.0042		0.023		0.00039		0.0020		0.000083		0.00033		0.00063		0.0050
H		0.0060		0.010		0.00072		0.0020		0.00043		0.00068		0.0010		0.0036
U ₁		0.0073		0.025		0.00082		0.0028		0.00043		0.00075		0.0011		0.0062
t-statistic		2.12		2.10		2.26		2.10		2.23		2.10		2.13		2.10
U ₂		0.016		0.053		0.0018		0.0060		0.0010		0.0016		0.0024		0.013
U ₃		0.0038		0.012		0.00058		0.0014		0.00029		0.00036		0.00061		0.0030
Certified		0.472		1.00		0.0100		0.081		0.0026		0.0087		0.0187		0.219
Uncertainty		0.004		0.01		0.0006		0.002		0.0003		0.0006		0.0008		0.003
Tolerance		0.016		0.05		0.0018		0.007		0.0010		0.0018		0.0030		0.013

BS 46B * Code for method Certified values listed as weight percent

Analysis	*	Sn	*	V	*	W
1	5	0.006133	4	0.004967	4	0.0005
2	4	0.006733	5	0.0055	3	0.0006
3	10	0.0069	3	0.0059	5	0.000657
4	5	0.007033	5	0.006367	5	0.00076
5	9	0.007033	4	0.006367	5	0.0008
6	5	0.00706	4	0.006617	10	0.0008
7	4	0.007067	10	0.0067	5	0.000807
8	4	0.0071	4	0.0070	4	0.0009
9	5	0.0073	5	0.007167	4	0.001033
10	5	0.007367	3	0.00789		
11	3	0.0075	14	0.007967		
12	3	0.0075	3	0.008		
13	3	0.0081	12	0.008167		
14			3	0.0085		
15			5	0.0086		
16			7	0.00870		
Average		0.00728		0.00726		0.00076
Std dev		0.00027		0.00032		0.00014
H		0.00063		0.00063		0.00029
U ₁		0.00068		0.00070		0.00032
t-statistic		2.18		2.13		2.31
U ₂		0.0015		0.0015		0.00074
U ₃		0.00041		0.00037		0.00025
Certified		0.0073		0.0073		0.0008
Uncertainty		0.0004		0.0009		0.0002
Tolerance		0.0015		0.0027		0.0007

BS 46B * Code for method Informational values listed as weight percent

Analysis	*	B	*	Mg	*	Nb	*	Pb	*	Sb	*	Ti	*	Zr
1	5	0.000072	3	0.00006	5	0.000233	5	0.0000733	5	0.001533	5	0.0005	5	0.00006
2	5	0.0001	3	0.00006	4	0.000667	5	0.0000767	5	0.001633	5	0.000577	5	0.000387
3	12	0.00012	4	0.0001	5	0.00076	12	0.0001013	5	0.00059	3	0.0006	3	0.0006
4	7	0.00021	5	0.000117	5	0.000773	9	0.0005	5	0.00060	4	0.000633	4	0.000633
5	4	0.000267	4	0.000233	5	0.00094	10	0.0010	3	0.0007	12	0.000833	12	0.000833
6	3	0.00028	4	0.000443	10	0.0024	3	0.0012	12	0.0010	10	0.0011	10	0.0011
7	3	0.0004	3	0.00089	12	0.002567	4	0.001233	4	0.0011	3	0.0016	3	0.0016
8	3	0.000417			4	0.0040	3	0.001725			14	0.001133	4	0.0018
9	3	0.00052			4	0.0043	3	0.0019			4	0.001133	3	0.003667
10	4	0.001			14	0.005167	3	0.0026			4	0.001333	4	0.0040
11	14	0.0030			3	0.00521	4	0.00325			3	0.0014		
12					3	0.0054					3	0.0021		
13					4	0.0056					4	0.00213		
14					3	0.0068					3	0.00226		
Average		0.00058		0.00027		0.003		0.0012		0.002		0.0012		0.0015
Std dev		0.00080		0.00021		0.013		0.0032		0.012		0.0053		0.0045
H		0.00027		0.00023		0.000		0.0003		0.000		0.00033		0.0004
U ₁		0.00084		0.00031		0.013		0.0033		0.012		0.0053		0.0046
t-statistic		2.23		2.45		2.16		2.23		12.71		2.16		2.26
U ₂		0.0019		0.00075		0.029		0.0073		0.15		0.011		0.010
U ₃		0.00056		0.00028		0.0077		0.0022		0.10		0.0031		0.0033
(Informational)		(0.0006)		(0.0003)		(0.003)		(0.001)		(0.002)		(0.001)		(0.002)

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 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 46B		* Code for analytical method				Trace analysis listed as mg/kg (ppm)			
Analysis	* Bi	* Ga	* Ge	* Re	* Zn				
1	3 54.5	5 8	5 23	5 0.61	12 10				
2	3 54.5	5 9	5 24	5 0.64	5 17				
3	3 84	5 9	5 24	5 0.76	5 18				
4	3 84	5 10	5 31		5 19				
5	3 96	5 11	5 35		5 19				
6	3 96	5 18	5 36		5 21				
7					5 22				
8					12 24				
9					12 25				

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

<u>Laboratory</u>	<u>Location</u>	<u>Registrar</u>	<u>Accreditation</u>
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
NSL Analytical	Cleveland, OH	ACLASS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Dirats Laboratories	Westfield, MA	ACLASS	17025
Exova	Glendale Heights, IL	A2LA	17025
TUV Rheinland India Pvt Ltd.	Kamataka, India	NBAL	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	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

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: 12XLA5, 12X722M24, 13X15023, 13X43100A; AR 668, 673, 872, 875, 1647, 1648, 1652, 1653; BAS 69, 111, 331, 406, 406/2, 407/1, 409, 460, 464/1; BS CSN 2-1, HON-T, SS4952, 30D, 46, 46A, 56H, 61G, 153, 316E, 410; CKD 170H, 184A, 187A; ECRM 039-2, 085-1, 86, 87, 296-1; IARM 36A, 36B, 38B, 41C, 42B, 238A, 299A; IMZ 112, 123, 160, 167, 170, 170; JK 31, 37; LECO 501-320, 501-501, 501-502, 501-503, 501-504, 501-644, 501-674, 501-676, 501-677, 501-993, 502-416; NCS NS20035B; SRM 15G, 36, 55D, 101C, 101E, 126, 129A, 133A, 133B, 160B, 160B, 343A, 361, 362, 363, 1265A, 1270, 1765, 1766.

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 4-94, 111, 406, 406-2, 407-1, 407-2; BS CSN 2-1, HON-T, 46, 46A; CKD 170G; ECRM 039-2; LECO 501-676; NCS NS20035B; SRM 361, 1265A, 1270, 1765, 1766.

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 46B 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 Steel Dynamics, Inc; Pittsboro, Indiana

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.

Certificate Number: The unique identification number for this certificate of analysis is 46B-030817. You may obtain information on

Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895
Telephone: (281) 440-9396 Fax: (281) 440-4432 Website: www.brammerstandard.com
 Certificate Number 46B-030817 Page 5/7

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. **Phone: (281) 440-9396** **Web: www.brammerstandard.com**
14603 Benfer Road
Houston, Texas 77069-2895 USA **Fax: (281) 440-4432** **Email: 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

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 30:2015 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 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, 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 March 08, 2017.

Beau R. Brammer

President