Brammer Standard Company, Inc.

Certificate of Analysis

BS 45B

Certified Reference Material for ASTM Steel Grade A182 F11 - UNS Number K11572

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.030**	0.002	**N**	**0.0066**	0.0005
As	**0.0066**	0.0006	**Ni**	**0.136**	0.006
C	**0.140**	0.004	**O**	**0.0015**	0.0005
Ca	**0.0008**	0.0003	**P**	**0.0068**	0.0008
Co	**0.0090**	0.0004	**S**	**0.017**	0.002
Cr	**1.14**	0.03	**Si**	**0.583**	0.009
Cu	**0.101**	0.001	**Sn**	**0.0069**	0.0004
Fe	**96.7**	0.2	**Ti**	**0.0024**	0.0004
Mn	**0.502**	0.006	**V**	**0.0083**	0.0007
Mo	**0.60**	0.01			

Informational Values[3,4]

B (0.0003)	Mg (0.0004)	Nb (0.002)	Pb (0.15)	Sb (0.003)
W (0.0038)	Zr (0.0009)			

[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 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 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 Ag, Bi, Ce, Cl, F, Ga, Ge, Hf, In, Ir, La, Na, Os, Re, Sr, Y, and Zn are shown on page 3.

The requirements of ISO Guides 30, 31, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis.

Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895
Telephone: (281) 440-9396 Fax (281) 440-4432 Website: www.brammerstandard.com

BS 45B * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo
1	10	0.0200	4	0.002	1	0.13	4	0.0005	12	0.0076	4	1.09533	18	0.092667	4	96.4533	18	0.47667	4	0.5827
2	12	0.02	3	0.005	1	0.132	12	0.00067	4	0.00783	14	1.09667	4	0.096833	10	96.597	4	0.48	7	0.589667
3	3	0.022967	12	0.0053	3	0.134	3	0.00067	8	0.00796	4	1.096967	3	0.097	4	96.63	4	0.491667	12	0.59
4	4	0.024833	5	0.006333	3	0.137	4	0.0008	3	0.0080	4	1.1133	14	0.099667	16	[96.66]	3	0.496	4	0.59
5	10	0.028	4	0.006433	1	0.137833	12	0.00085	5	0.008733	4	1.118	12	0.100	10	96.66	4	0.496367	4	0.593
6	4	0.028267	4	0.006567	1	0.138	4	0.0009	4	0.008767	10	1.13	10	0.1	18	96.6633	4	0.49833	4	0.59333
7	5	0.028667	14	0.006767	4	0.138667	4	0.000903	10	0.0088	4	1.13	4	0.10	3	96.665	4	0.499	4	0.594
8	4	0.029	4	0.007	1	0.139	14	0.001233	4	0.0090	12	1.13	4	0.10	4	96.6667	4	0.499667	10	0.59733
9	4	0.029133	5	0.007	1	0.139667			3	0.009	4	1.13333	4	0.10	16	[96.67]	4	0.50	14	0.59833
10	3	0.0292	10	0.0071	4	0.14			10	0.009	4	1.13667	4	0.100333	3	96.6833	3	0.5	4	0.599667
11	14	0.0297	4	0.007217	1	0.141			5	0.009	3	1.14667	3	0.101	16	[96.733]	12	0.500	3	0.601
12	4	0.029733	3	0.0073	1	0.143			3	0.0091	10	1.1590	4	0.101667	14	96.7667	4	0.50007	4	0.604467
13	4	0.030633	5	0.007533	1	0.144033			14	0.009133	3	1.1590	4	0.101733	4	96.76673	3	0.501	4	0.608667
14	3	0.031	12	0.007967	1	0.144667			4	0.009167	4	1.16	10	0.102	13	96.841	14	0.50233	3	0.610
15	4	0.0312			1	0.145267			4	0.0092	3	1.16	4	0.102	4	96.9	10	0.504	3	0.614
16	18	0.032			1	0.16833			4	0.01	3	1.16	10	0.102	12	96.9	8	0.504667	3	0.616
17	12	0.0330			1	0.1800			4	0.010	10	1.16	4	0.103667	4	96.9	10	0.506	10	0.618
18	4	0.033667			1	0.18233			10	0.01023	4	1.164667	3	0.104	4	96.9333	4	0.50667	4	0.623
19	3	0.034							3	0.0103	4	1.17	4	0.104			10	0.507667	4	0.62333
20									12	0.0120	13	1.177667	8	0.104			4	0.509667	10	0.624
21											18	1.18	3	0.105			3	0.512		
22											4	1.186667					4	0.58		
23											4	1.196667								
Average		0.02967		0.00657		0.1399		0.000753		0.00899		1.1593		0.1006		96.665		0.5040		0.6077
Std Dev		0.00088		0.00027		0.0030		0.000040		0.00027		0.0052		0.0022		0.024		0.0038		0.0045
H		0.0013		0.00067		0.0030		0.00032		0.00076		0.0114		0.0024		0.45		0.0065		0.0074
U_1		0.0016		0.00072		0.0042		0.00033		0.00081		0.013		0.0033		0.45		0.0076		0.0087
t-statistic		2.10		2.16		2.11		2.36		2.09		2.07		2.09		2.11		2.08		2.09
U_2		0.0033		0.0016		0.0089		0.00077		0.0017		0.026		0.0068		0.94		0.016		0.018
U_3		0.00076		0.00042		0.0021		0.00027		0.00038		0.0054		0.0015		0.22		0.0034		0.0040
Certified		**0.030**		**0.0066**		**0.140**		**0.0008**		**0.0090**		**1.14**		**0.101**		**96.7**		**0.502**		**0.60**
Uncertainty		0.002		0.0006		0.004		0.0003		0.0004		0.03		0.001		0.2		0.006		0.01
Tolerance		0.006		0.0018		0.012		0.0008		0.0017		0.09		0.007		0.9		0.018		0.03

Analysis	*	N	*	Ni	*	O	*	P	*	S	*	Si	*	Sn	*	Ti	*	V
1	2	0.0059	4	0.129133	2	0.000933	12	0.005	12	0.013	3	0.56433	10	0.005	12	0.0014	3	0.007
2	2	0.006267	14	0.129667	2	0.000967	5	0.00533	3	0.0148	4	0.566	12	0.0056	5	0.002	10	0.0075
3	2	0.006437	4	0.13	2	0.001	10	0.0057	1	0.014933	6	0.57333	12	0.006767	10	0.002	4	0.00764
4	2	0.006477	12	0.13	2	0.00101	3	0.0057667	4	0.015	3	0.576	5	0.0069	4	0.0020333	3	0.0078
5	2	0.006547	3	0.13	4	0.0016	4	0.005783	1	0.0153	14	0.57633	9	0.0069	4	0.0020333	4	0.007867
6	2	0.006567	4	0.13	2	0.001633	10	0.006	1	0.01533	6	0.57667	4	0.0069667	4	0.0021667	10	0.008
7	2	0.0066	4	0.13033	2	0.001757	4	0.006	1	0.015467	18	0.57667	4	0.007	14	0.0022	3	0.008
8	2	0.006693	8	0.131	2	0.001993	3	0.007	1	0.015667	4	0.5774	5	0.007	12	0.0022667	5	0.008
9	2	0.006767	4	0.132	2	0.0023	3	0.007	1	0.015833	3	0.58	4	0.0070	5	0.00234	4	0.008233
10	2	0.006833	4	0.13223	2	0.0025	4	0.007033	3	0.016	10	0.58	3	0.0073	4	0.0024267	3	0.0083
11			10	0.132667			7	0.00707	1	0.0162	4	0.58267	5	0.00731	3	0.0025	5	0.0087
12			10	0.133			5	0.007133	1	0.0169	10	0.58633	10	0.0078	3	0.0025	4	0.009
13			3	0.133			10	0.0073	10	0.017	4	0.59013	3	0.008	4	0.0025667	10	0.0090
14			4	0.1333			12	0.007367	3	0.018	4	0.59233	3	0.008	5	0.0025667	4	0.0090
15			3	0.134			4	0.007633	4	0.018	4	0.59433	5	0.0083	4	0.003	12	0.009033
16			4	0.13533			4	0.008033	1	0.0180	3	0.595			3	0.003	14	0.009033
17			3	0.136			14	0.008167	1	0.018267	10	0.599			10	0.003	4	0.009267
18			4	0.139			4	0.009	1	0.0188	4	0.61667						
19			5	0.14033			4	0.009	12	0.0190	4	0.63						
20			4	0.14667			3	0.0091	1	0.020	12	0.63						
21			18	0.146667														
Average		0.00656		0.1358		0.001462		0.00677		0.01665		0.5825		0.00692		0.002353		0.00833
Std Dev		0.00026		0.0026		0.000095		0.00016		0.00055		0.0048		0.00027		0.000077		0.00028
H		0.00067		0.0029		0.00039		0.00068		0.0010		0.0072		0.00068		0.0004572		0.00073
U_1		0.00072		0.0039		0.00040		0.00069		0.0011		0.0086		0.00073		0.00046		0.00079
t-statistic		2.26		2.09		2.26		2.09		2.09		2.09		2.14		2.12		2.12
U_2		0.0016		0.0081		0.00091		0.0015		0.0024		0.018		0.0016		0.00098		0.0017
U_3		0.00051		0.0018		0.00029		0.00032		0.00053		0.0040		0.00041		0.00024		0.00041
Certified		**0.0066**		**0.136**		**0.0015**		**0.0068**		**0.017**		**0.583**		**0.0069**		**0.0024**		**0.0083**
Uncertainty		0.0005		0.006		0.0005		0.0008		0.002		0.009		0.0004		0.0004		0.0007
Tolerance		0.0016		0.018		0.0015		0.0024		0.006		0.027		0.0016		0.0012		0.0021

BS 45B * Code for method Informational values listed as weight percent

Analysis	*	B	*	Mg	*	Nb	*	Pb	*	Sb	*	W	*	Zr
1	12	0.000085	12	0.00014	12	0.000130	12	0.000043	12	0.0024	4	0.001	12	0.000037
2	4	0.0001	5	0.0002	12	0.000177	10	0.001	4	0.002833	5	0.001	5	0.00006
3	12	0.00013	4	0.0002	5	0.0002	12	0.4433	12	0.0039	5	0.001093	12	0.0000623
4	5	0.000167	12	0.000213	5	0.00025					5	0.001233	5	0.000133
5	3	0.00031	3	0.00038	4	0.000567					12	0.001433	4	0.0010
6	4	0.001133	4	0.000443	4	0.000633					3	0.0038	4	0.0010333
7			3	0.001	3	0.001					4	0.003967	3	0.0015
8					4	0.001033					4	0.003967	10	0.0019
9					3	0.0014					14	0.0041	3	0.002
10					4	0.0015					4	0.004767		
11					5	0.002927					4	0.005		
12					4	0.003								
13					10	0.006								
14					4	0.0062								
Average		0.00032		0.00037		0.0018		0.15		0.003		0.0038		0.0009
Std Dev		0.00032		0.00040		0.0053		1.12		0.027		0.0010		0.0019
H		0.00026		0.00027		0.0004		0.00		0.000		0.0005		0.0003
U_1		0.00041		0.00048		0.0054		1.12		0.027		0.0011		0.0019
t-statistic		2.57		2.45		2.16		4.30		4.30		2.23		2.31
U_2		0.0011		0.0012		0.012		4.83		0.11		0.0025		0.0043
U_3		0.00044		0.00044		0.0031		2.79		0.066		0.00076		0.0014
Informational		(0.0003)		(0.0004)		(0.002)		(0.15)		(0.003)		(0.0038)		(0.0009)

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 it's 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:

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

*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 45B * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ag	*	Bi	*	Ce	*	Cl	*	F	*	Ga	*	Ge	*	Hf	*	In	*	Ir
1	12	0.26	12	0.01	12	0.01	12	0.03	12	0.3	12	8.8	12	5.7	12	0.02	12	0.26	12	0.01
2	12	0.27			12	0.02	12	0.03	12	0.4	12	9.5	12	37			12	0.27	12	0.01
3	12	0.32			12	0.02	12	0.03	12	0.4	12	9.6	12	37					12	0.02
4	12	0.47			12	0.03					12	11	12	38					12	0.04

Analysis	*	La	*	Na	*	Os	*	Re	*	Sr	*	Y	*	Zn
1	12	0.008	12	0.03	12	0.01	12	0.37	12	0.02	12	0.006	12	2.2
2			12	0.2			12	0.47					12	2.4
3			12	0.2			12	0.47					12	2.4
4			12	0.2			12	0.51					12	2.6

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	18	PIXE
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
LECO Corporation	St. Joseph, MI	A2LA	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Exova	Glendale Heights, Il	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
TUV Rheinland India Pvt Ltd	Bangalore, India	NABL	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	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: 12X10180, 12X152535, 12X358, 12X41450, 12XLA2, 12XLA3, 13X12859, 13X14211, 13X18004, 13X31254, 13X31254, 13X41001, 13X43100, 13XNSC3, 14XMN2, 14XMN4, 219X0882, 219X8825; AR 642, 654, 657, 659, 670, 676, 872, 875, 960, 1648, 1652, 1653; BAS 4/88, 320, 408, 409, 434M 434/2, 451, 464/1; BS CCS-2, H3C, 45, 45A, 55D, 201, 718D, 1026, 1981, 1982, 9325A; CKD 169A, 170H, 180A; ECRM 86, 87; IARM 32D, 33D, 35E, 35H, 35I, 59A, 62E; IMZ 1-N4, 112; JK 8F, 21, 37; LECO 501-320, 501-501, 501-502, 501-503, 501-504, 501-550, 501-644, 501-675, 501-676, 501-993, 502-411, 502-704, 502-855, 502-870, 502-873, 502-895; NCS NS20035B; SRM 19f, 132a, 160b, 291, 361, 362, 363, 364, 1763A; Y 41340B.

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 4/88, 409; BS 45, 45A, 55D, 1981, 1982; ECRM 230-4; LECO 501-676, 502-873; NCS NS20035B; SRM 291; Y 41340B.

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 45B 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 Metal Ravne d.o.o.; Slovenia, EU.

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 45B-072117. 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. **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 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 9001:2008 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 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 July 21, 2017.

Beau R. Brammer

President