

Brammer Standard Company, Inc.

Certificate of Analysis

BS 183C

Certified Reference Material for Greek Ascology - UNS Number S41800

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0020	0.0005		N	0.003
As	0.0041	0.0004		Nb	0.0006
C	0.173	0.003		Ni	0.01
Ca	0.0006	0.0003		P	0.001
Co	0.027	0.002		S	0.0005
Cr	12.72	0.08		Sb	0.0003
Cu	0.060	0.004		Si	0.009
Fe	81.1	0.1		Sn	0.0008
Mn	0.368	0.008		V	0.005
Mo	0.189	0.007		W	0.08
	Reference Value ¹	Estimate of Uncertainty ²	Reference Values^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
O	0.005	0.001		Ti	0.001

Informational Values^{3,5}

B (0.0008)

Mg (0.0002)

Pb (0.0002)

Ta (0.003)

Zr (0.0005)

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.

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

Trace element information values for Ce, Ga, Ge, Ir, La, Na, Os, Re, 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.

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Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo
1	12	0.0010667	3	0.0036	1	0.164	12	0.00033667	4	0.02283333	4	12.61	4	0.05485	10	80.92	3	0.354	8	0.18
2	4	0.0012667	3	0.0036	1	0.1666666667	4	0.0004	4	0.02285	3	12.67	5	0.05573333	3	80.96666667	10	0.36	10	0.18
3	11	0.0015	5	0.0037333	11	0.17	8	0.00053333	4	0.0233	4	12.695	10	0.056	13	81.009	8	0.36	4	0.182
4	5	0.0016667	9	0.0037667	1	0.17	4	0.00055	4	0.02346667	13	12.698	4	0.056	16	[81.0301]	4	0.36166667	4	0.182
5	5	0.0017833	11	0.0038	11	0.17	11	0.0006	5	0.0245	4	12.7061333	4	0.05613333	16	[81.07]	11	0.365	11	0.185
6	4	0.0020333	11	0.0039	4	0.1702333333	11	0.0006	4	0.02456667	4	12.7077333	4	0.05703333	16	[81.0703834]	11	0.365	11	0.185
7	4	0.0020333	5	0.0039667	1	0.1706666667	14	0.0007	7	0.02496667	4	12.71	4	0.05746667	10	81.07633333	4	0.36566667	4	0.18533333
8	3	0.0023	4	0.0040	1	0.1712	4	0.00083667	4	0.02596667	3	12.71	3	0.058	4	81.12	3	0.366	3	0.187
9	3	0.0023	4	0.00405	1	0.1713333333			3	0.0263	4	12.7166667	11	0.0588	16	[81.13]	3	0.366	4	0.1877
10	14	0.0027667	12	0.0041	1	0.1713333333			8	0.027	4	12.7166667	4	0.0595	16	[81.13]	7	0.36666667	10	0.18933333
11	4	0.0028	4	0.0041667	1	0.172			4	0.027	3	12.72	3	0.05963333	14	81.16666667	4	0.367	3	0.19
12			5	0.0042	1	0.1736666667			3	0.0271	3	12.72	8	0.05983333	16	[81.18]	10	0.369	4	0.19033333
13			4	0.0045	1	0.1746666667			8	0.0271	4	12.7233333	8	0.060	4	81.19153333	4	0.36933333	4	0.19033333
14			15	0.0048033	3	0.175			3	0.0275	17	12.73	10	0.06033333	16	[81.24]	3	0.37	4	0.1909
15			5	0.0050267	1	0.1750466667			3	0.0275	10	12.73	10	0.06033333	16	[81.24]	4	0.37166667	3	0.191
16					1	0.1759333333			4	0.02773333	14	12.7333333	4	0.06046667	4	81.385	4	0.37163333	3	0.191
17					3	0.176			11	0.028	10	12.7586667	11	0.0614	4	0.37225	4	0.37225	4	0.19136667
18					3	0.176			11	0.028	13	12.76	3	0.062	4	0.373	4	0.373	4	0.1915
19					1	0.1863333333			4	0.02816667	17	12.7785333	4	0.06313333	4	0.3736	10	0.19266667	10	0.19266667
20									14	0.0282	11	12.8	3	0.0647	4	0.37506667	14	0.194	14	0.194
21									10	0.031	11	12.82	3	0.0647	3	0.377	3	0.377	3	0.194333
22									10	0.031667	10	12.82333	4	0.064733	10	0.380667	7	0.196667	7	0.196667
23													14	0.0649					5	0.204333
Average		0.001956		0.00411		0.1730		0.00057		0.02676		12.7171		0.059812		81.128		0.3677		0.1892
Std Dev		0.000095		0.00013		0.0028		0.00011		0.00072		0.0038		0.000066		0.035		0.0034		0.0026
H		0.00055		0.00074		0.0042		0.00035		0.0017		0.049		0.0025		0.17		0.0062		0.0044
U ₁		0.00056		0.00075		0.0050		0.00036		0.0018		0.050		0.0025		0.17		0.0071		0.0051
t-statistic		2.23		2.14		2.10		2.36		2.08		2.08		2.07		2.13		2.08		2.07
U ₂		0.0012		0.0016		0.011		0.00086		0.0038		0.10		0.0051		0.37		0.015		0.011
U ₃		0.00038		0.00042		0.0024		0.00030		0.00081		0.022		0.0011		0.091		0.0032		0.0022
Certified		0.0020		0.0041		0.173		0.0006		0.027		12.72		0.060		81.1		0.368		0.189
Uncertainty		0.0005		0.0004		0.003		0.0003		0.002		0.08		0.004		0.1		0.008		0.007
Tolerance		0.0015		0.0016		0.009		0.0005		0.006		0.24		0.012		0.3		0.024		0.021

Analysis	*	N	*	Nb	*	Ni	*	P	*	S	*	Sb	*	Si	*	Sn	*	V	*	W
1	2	0.0346	4	0.0035	3	1.85	7	0.01306667	11	0.0029	5	0.00038	4	0.4095	11	0.0029	10	0.10	10	2.70
2	2	0.0362	12	0.0038667	3	1.85	10	0.01346667	3	0.0035	5	0.0005	3	0.411	5	0.002933333	8	0.10	8	2.73275
3	2	0.037	10	0.004	10	1.86	4	0.01396667	1	0.0036	12	0.00052333	3	0.411	4	0.0030	10	0.10266667	14	2.76
4	2	0.0379	5	0.0048867	4	1.8656	3	0.01396667	12	0.00366667	9	0.0006	17	0.4178	4	0.003266667	4	0.1055	4	2.76896667
5	2	0.0382333	4	0.0050133	14	1.8666666667	4	0.01413333	1	0.00372	5	0.00062333	3	0.42	3	0.0034	4	0.10775	4	2.77176667
6	2	0.0382667	5	0.0053667	4	1.8695	4	0.01423333	1	0.00376667	3	0.0008	3	0.420	3	0.0036	5	0.108	11	2.78
7	2	0.0382667	5	0.0055333	4	1.8696	12	0.01466667	10	0.0038	4	0.00103333	10	0.42666667	3	0.0036	3	0.1081	4	2.785
8	13	0.0387333	3	0.0056	11	1.87	10	0.01466667	1	0.0038	11	0.0011	4	0.427	12	0.003966667	4	0.10883333	11	2.79
9	2	0.0389	3	0.0056	11	1.87	4	0.015	1	0.0039	4	0.00113333	4	0.42833333	11	0.004	4	0.109	4	2.798
10	2	0.0390	11	0.0057	4	1.87	4	0.0153	1	0.00396667	4	0.42866667	4	0.42866667	4	0.004333333	10	0.109	3	2.8
11	2	0.04	4	0.0058667	4	1.8754666667	4	0.01533333	1	0.004	10	0.42866667	4	0.42866667	4	0.004333333	3	0.10933333	3	2.8
12	2	0.0409333	4	0.0060	4	1.876	17	0.016	1	0.00403333	4	0.42926667	9	0.004366667	3	0.11	10	0.110	10	2.805
13	2	0.041	14	0.0068333	10	1.88	5	0.0160	1	0.0043	4	0.42966667	5	0.004366667	4	0.11036667	4	0.11036667	10	2.82266667
14	4	0.0436667	11	0.0087	3	1.88	4	0.0161	3	0.0044	4	0.42996667	5	0.004726667	3	0.111	3	0.111	3	2.83666667
15					17	1.88	11	0.0164	3	0.0044	10	0.43	5	0.004766667	3	0.111	8	0.111	8	2.85525
16					4	1.8803333333	3	0.0164	1	0.00448	17	0.43	5	0.005333333	4	0.1117	4	0.1117	4	2.87333333
17					10	1.8806666667	3	0.0164	1	0.0045	14	0.431	11	0.112	11	0.112	4	0.112	4	2.87513333
18					4	1.8815666667	11	0.0165	1	0.0047	4	0.433	4	0.433	11	0.112	4	0.112	4	2.88
19					4	1.8833333333	3	0.0168	1	0.00493333	4	0.434	14	0.11233333	14	0.11233333	4	0.11233333	4	2.89775
20					4	1.891	3	0.017	3	0.017	3	0.43533333	4	0.11413333	4	0.11413333	4	0.11413333	4	2.89866667
21					3	1.903333	10	0.018					11	0.445	4	0.11413333	4	0.11413333	4	2.901667
22													11	0.445					3	2.91
23																			4	2.936667
24																			10	2.983333
Average		0.0385		0.00538		1.8695		0.01549		0.004019		0.00074		0.4266		0.00393		0.108636		2.831776
Std Dev		0.0012		0.00020		0.0045		0.00051		0.000073		0.00011		0.0039		0.00010		0.000071		0.000065
H		0.0020		0.00083		0.015		0.0013		0.00074		0.00038		0.0068		0.00073		0.0033		0.020
U ₁		0.0023		0.00085		0.016		0.0014		0.00074		0.00040		0.0078		0.00074		0.0033		0.020
t-statistic		2.16		2.16		2.09		2.09		2.10		2.31		2.08		2.13		2.09		2.07
U ₂		0.0050		0.0018		0.034		0.0029		0.0016		0.00091		0.016		0.0016		0.0069		0.041
U ₃		0.0013		0.00049		0.0073		0.00064		0.00036		0.00030		0.0035		0.00039		0.0016		0.0083
Certified		0.039		0.0054		1.87		0.015		0.0040		0.0007		0.427		0.0039		0.109		2.83
Uncertainty		0.003		0.0006		0.01		0.001		0.0005		0.0003		0.009		0.0008		0.005		0.08
Tolerance		0.009		0.0018		0.03		0.003		0.0015		0.0006		0.027		0.0024		0.015		0.024

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* Code for method

Reference values listed as weight percent

Analysis	*	O	*	Ti
1	2	0.0040	5	0.0010667
2	2	0.0040	5	0.00116
3	16	0.0042	4	0.00125
4	2	0.0047733	4	0.0013333
5	2	0.005	14	0.0021
6	2	0.005	4	0.0022
7	2	0.0051667	4	0.0022333
8	2	0.0054667	3	0.0026
9	2	0.0057667	3	0.0026
10	2	0.0058	11	0.0028
11			4	0.0028
Average		0.00485		0.002013
Std Dev		0.00023		0.000095
H		0.00079		0.00056
U ₁		0.00083		0.00056
t-statistic		2.26		2.23
U ₂		0.0019		0.0013
U ₃		0.00059		0.00038
Reference		0.005		0.002
Uncertainty		0.001		0.001
Tolerance		0.003		0.001

BS 183C

* Code for method

Informational values listed as weight percent

Analysis	*	B	*	Mg	*	Pb	*	Ta	*	Zr
1	4	0.00015	4	0.00004	5	0.00001	4	0.00125	12	0.00022
2	7	0.0001733	12	0.00013	12	0.0000113	4	0.00356667	3	0.0003
3	5	0.00018	8	0.0001333	3	0.0002	4	0.00383333	3	0.0003
4	12	0.00018	4	0.0002	3	0.0002	10	0.00466667	4	0.00052667
5	3	0.0002	4	0.00029	11	0.0003			11	0.0008
6	3	0.0003	4	0.0003	4	0.0004233333			4	0.0009
7	3	0.0003			9	0.0004333333				
8	4	0.0004								
9	14	0.0009								
10	4	0.0010667								
11	2	0.0011333								
12	11	0.0021								
13	11	0.0034								
Average		0.0008		0.000182		0.00023		0.003		0.00051
Std Dev		0.0014		0.000093		0.00014		0.026		0.00083
H		0.0004		0.00023		0.00025		0.001		0.00033
U ₁		0.0014		0.00025		0.00029		0.026		0.00089
t-statistic		2.18		2.57		2.45		3.18		2.57
U ₂		0.0031		0.00065		0.00071		0.084		0.0023
U ₃		0.00086		0.00027		0.00027		0.042		0.00094
Informational		(0.0008)		(0.0002)		(0.0002)		(0.003)		(0.0005)

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.

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* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ce	*	Ga	*	Ge	*	Ir	*	La	*	Na	*	Os	*	Re	*	Y	*	Zn
1	12	0.008	12	15	12	10	12	0.04	12	0.006	12	0.03	12	0.04	12	0.2	12	0.01	12	0.8
2	12	0.01	12	17	12	10	12	0.04	12	0.008	12	0.03	12	0.04	12	0.22	12	0.02	12	0.81
3	12	0.01	12	18	12	10	12	0.05			12	0.03	12	0.05	12	0.23	12	0.02	12	0.82

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
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Luvak Inc.	Boylston, MA	PRI	17025
Vitkovice Testing Center	Ostrava, Czech Republic	ILAC	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Carpenter Technology Corporation	Reading, PA	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Shiva Analyticals	Hoskote, Bangalore	NABL	17025

A2LA = American Association for Laboratory Accreditation

ANAB = ANSI-ASQ National Accreditation Board

CNAS = China National Accreditation Service

ILAC = International Laboratory Accreditation Cooperation

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: 12X15259Q, 12X3490, 12X4330A, 13X12853K, 13X14212, 13X14212L, 13X14215L, 13X14418A, 13X14775S, 13X31603D, 13X32100, 13X32900, 13X32900A, 13X4100A, 13X41800, 13X41800A, 13X42200, 14X93603A, 23X80010; AR 165, 641, 654, 659, 662, 675, 871, 882, 892, 960, 1648, 1650, 1652, 1653; BAS 69, 72, 342, 386, 424, 435, 451, 464/1, 469; BS CSN-2, H-13, H-19, H1C, 17-4PHA, 50G, 97, 183, 185A, 186A, 187C, 187D, 200-1, 200-2, 200-4, 200A, 316D, 431, 800A, 4340A, 9905A; CKD 186A; DSZU CA013; ECRM 085-1, 179-1, 179-2, 184-1, 288-1; IARM 20A, 20C, 22B, 90B, 91B, 205B; IMN BB1; IMZ 123, 161, 162, 196; IPT 12A, 17A; JK 37; JSS 169-5, 174-5, 175-7; LECO 501-503, 501-506, 501-644, 501-646, 501-673, 502-257, 502-712, 502-868, 502-916, 502-921; APL 16A; SRM 33D, 121D, 126C, 132, 132B, 133B, 134A, 139B, 160B, 293, 343A, 344, 345, 346A, 348, 348A, 361, 362, 363, 866, 1219, 1261, 1295, 1761, 1762, 3155.

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: 13X41800; BAS 386, 424, 451; BS CSN-2, H-19, 97, 183; DSZU CA013; ECRM 179-1, 179-2, 184-1, 288-1; IARM 20A, 20C, 205B; IMZ 161, 196; JK 37; LECO 502-257; SRM 121D, 126C, 132B, 134A, 160B, 293, 344, 345, 346A, 348, 348A, 362, 866, 1219, 1295.

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 183B 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 Crucible Specialty Metals; Syracuse, New York.

Form: This CRM is machined in the form of a disc, approximately 38mm in diameter and 19mm 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 183C-123120. 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:

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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 December 31, 2020.

Beau R. Brammer

President