

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 936

Certified Reference Material for Bronze CDA 936 - UNS Number C93600

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values ³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0007	0.0003	Pb	10.7	0.2
As	0.0045	0.0003	S	0.009	0.001
Cu	81.5	0.2	Sb	0.102	0.002
Fe	0.0026	0.0003	Si	0.0040	0.0005
Ni	0.36	0.01	Sn	6.99	0.02
O	0.0026	0.0003	Zn	0.244	0.005

	Reference Value ¹	Estimate of Uncertainty ²	Reference Values ⁴	Reference Value ¹	Estimate of Uncertainty ²
C	0.0025	0.0002	P	0.053	0.001

Informational Values^{3,5}

Co (0.003) Cr (0.00004) Mn (0.0006) N (0.0001) Ti (0.00006)

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 Ag, Au, Bi, Cd, In, Na, Se, Ta, and Te 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 936 * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	Cu	*	Fe	*	Ni	*	O	*	Pb [#]	*	S
1	3	0.000375	5	0.002967	16	[80.8825]	5	0.0016	3	0.3325	2	0.002125	10	9.963333	1	0.005733
2	4	0.0007	5	0.003433	16	[81.0575]	12	0.0018	5	0.334	2	0.002273	3	10.225	1	0.006767
3	4	0.000767	4	0.003833	4	81.19707	4	0.002533	12	0.3360	2	0.0023	3	10.4075	1	0.007267
4	3	0.0008	3	0.003975	14	81.2	3	0.00255	5	0.336633	2	0.00256	4	10.46667	1	0.0077
5	14	0.000933	5	0.0041	13	81.30867	4	0.002567	3	0.3375	2	0.002667	4	10.48667	1	0.008
6	3	0.00095	4	0.004167	16	[81.33333]	5	0.002933	3	0.33775	2	0.0028	4	10.56667	1	0.008033
7	3	0.00105	3	0.00425	16	[81.335]	3	0.003575	3	0.345	2	0.0029	4	10.64	1	0.0092
8	3	0.001275	5	0.004333	16	[81.415]	3	0.003625	5	0.3450	2	0.00295	4	10.65233	1	0.00927
9			3	0.00445	10	81.49333	3	0.004875	4	0.347667	2	0.0035	3	10.8275	3	0.00995
10			12	0.0045	16	[81.64333]	3	0.00515	14	0.348			3	10.84	1	0.010633
11			9	0.005133	4	81.65333	3	0.0059	4	0.35			4	10.85274	1	0.0113
12			3	0.0054	4	81.66667			4	0.350767			14	11.0	3	0.01195
13			3	0.005625	4	81.73333			4	0.3542			4	11.04317	3	0.0124
14			3	0.006	4	81.78667			4	0.354467			3	11.155	3	0.013275
15					16	[81.8375]			3	0.3575			3	11.215	3	0.01345
16					3	82.03			3	0.36125					1	0.01345
17									3	0.3635					3	0.0136
18									4	0.366333						
19									8	0.368667						
20									4	0.386667						
21									10	0.39						
Average		0.00068		0.00446		81.475		0.00262		0.3618		0.002637		10.69		0.00955
Std dev		0.00011		0.00020		0.037		0.00027		0.0043		0.000074		0.25		0.00032
H		0.000281		0.000508		0.44943		0.00042		0.004943		0.000421		0.066432		0.00069
U ₁		0.00030		0.00055		0.45		0.00050		0.0066		0.00043		0.26		0.00076
t-statistic		2.36		2.16		2.13		2.23		2.09		2.31		2.14		2.12
U ₂		0.00071		0.0012		0.96		0.0011		0.014		0.00099		0.56		0.0016
U ₃		0.00025		0.00031		0.24		0.00033		0.0030		0.00033		0.14		0.00039
Certified		0.0007		0.0045		81.5		0.0026		0.36		0.0026		10.7		0.009
Uncertainty		0.0003		0.0003		0.2		0.0003		0.01		0.0003		0.2		0.001
Tolerance		0.0007		0.0012		1.0		0.0011		0.04		0.0010		0.6		0.004

Unweighted mean and standard deviation were used to calculate Lead. The weighted mean is 10.8510 and standard deviation is 0.0043. The weighted certified value is 10.85 with an uncertainty of 0.04 and tolerance of 0.14.

BS 936 * Code for method Certified values listed as weight percent

Analysis	*	Sb	*	Si	*	Sn	*	Zn
1	4	0.09345	3	0.002975	4	6.886667	12	0.2300
2	5	0.095233	3	0.0031	4	6.913667	3	0.2355
3	3	0.09785	3	0.004	14	6.953333	5	0.235933
4	3	0.0985	3	0.00415	4	6.958233	5	0.236333
5	3	0.09875	3	0.00415	4	6.969333	3	0.2385
6	3	0.1	3	0.0049	3	6.975	5	0.239467
7	4	0.10	3	0.005	3	6.985	3	0.23975
8	4	0.10	14	0.0054	3	6.985	3	0.23975
9	4	0.100167			3	6.99	4	0.2412
10	3	0.10125			4	6.991033	3	0.24225
11	4	0.101333			3	7.0025	4	0.243333
12	4	0.102167			4	7.01	3	0.24425
13	5	0.103767			4	7.026667	4	0.247
14	14	0.104			4	7.033333	4	0.249167
15	4	0.107			3	7.0575	4	0.252
16	5	0.108333			3	7.0925	14	0.254333
17	3	0.109			10	7.746667	4	0.2549
18	4	0.1094					10	0.256667
19	12	0.1095					3	0.256667
20							3	0.26225
Average		0.1020		0.00396		6.9946		0.2442
Std dev		0.0023		0.00029		0.0057		0.0035
H		0.002261		0.000486		0.046079		0.003835
U ₁		0.0032		0.00057		0.046		0.0052
t-statistic		2.10		2.36		2.12		2.09
U ₂		0.0068		0.0013		0.098		0.011
U ₃		0.0016		0.00047		0.024		0.0024
Certified		0.102		0.0040		6.99		0.244
Uncertainty		0.002		0.0005		0.02		0.005
Tolerance		0.007		0.0013		0.10		0.015

BS 936 * Code for method Reference values listed as weight percent

Analysis	*	C	*	P
1	1	0.0003	3	0.0409
2	1	0.001667	4	0.043133
3	3	0.002225	3	0.043725
4	1	0.002333	3	0.0449
5	3	0.00235	3	0.045525
6	3	0.002575	3	0.047
7	1	0.002667	3	0.048975
8	3	0.0027	5	0.051667
9	1	0.002963	5	0.0534
10	3	0.0045	7	0.054867
11	3	0.0045	5	0.055733
12	1	0.006833	12	0.0575
13	1	0.0074	3	0.05825
14	1	0.007433	3	0.0586
15	3	0.009	4	0.062367
16			4	0.063067
17			4	0.063733
18			7	0.0646
Average		0.00246		0.0528
Std dev		0.00015		0.0014
H		0.000411		0.001568
U ₁		0.00044		0.0021
t-statistic		2.14		2.11
U ₂		0.00094		0.0044
U ₃		0.00024		0.0010
Reference		0.0025		0.053
Uncertainty		0.0002		0.001
Tolerance		0.0009		0.010

BS 936 * Code for method Informational values listed as weight percent

Analysis	* Co	* Cr	* Mn	* N	* Ti
1	5 0.000247	12 0.000032	12 0.0000058	2 0.0000737	12 0.0000010
2	12 0.00027	5 0.000048	4 0.0002333	2 0.0001	5 0.00011
3	5 0.000393		3 0.0003	2 0.0002333	
4	5 0.0004		3 0.0005		
5	4 0.0004		3 0.000575		
6	5 0.000477		3 0.000625		
7	5 0.000823		3 0.000725		
8	14 0.001067		3 0.00095		
9	4 0.001333		3 0.0010		
10	3 0.00535		4 0.0015333		
11	3 0.00555				
12	3 0.00615				
13	3 0.00615				
14	3 0.0067				
15	3 0.0076				
16	3 0.007875				
Average	0.003	0.0000363	0.0006	0.000136	0.000056
Std dev	0.012	0.0000055	0.0010	0.000067	0.000018
H	0.00044	0.000175	0.000272	0.000202	0.000181
U ₁	0.012	0.00018	0.0011	0.00021	0.00018
t-statistic	2.13	12.71	2.26	4.30	12.71
U ₂	0.026	0.0022	0.0024	0.00092	0.0023
U ₃	0.0065	0.0016	0.00076	0.00053	0.0016
(Informational)	(0.003)	(0.00004)	(0.0006)	(0.0001)	(0.00006)

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. U₁ is the combined uncertainty from homogeneity and labs. U₂ is U₁ multiplied by the coverage factor (95 % t-statistic). U₃ is U₂ 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 U₃ 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.

BS 936 * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	* Ag	* Au	* Bi	* Cd	* In	* Na	* Se	* Ta	* Te
1	5 227	12 0.67	12 200	5 1.0	12 3	12 0.021	12 3.2	5 0.8	5 0.9
2	5 231		5 208	5 1.0	12 3		5 3.8		5 0.9
3	5 237		5 209	5 1.0	12 4		5 3.9		5 0.9
4	5 291		5 210				5 3.9		12 4.2
5	5 302		5 240				5 3.9		5 4.5
6	12 305		4 240.3				5 3.9		5 4.6
7	5 312		5 258				5 4.0		5 4.6
8	4 330		5 259						

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
Luvak, Inc.	Boylston, MA	PRI/Nadcap	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Dirats Laboratories	Westfield, MA	ACCLASS	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
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
PRI = Performance Review Institute

Analysis: Chemical analyses were made on solid pieces and chips prepared by a lathe 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: 501-149, 501-676, 502-257, 502-403, 502-494, 502-991; AR 89, 147, 614A, 645, 657, 662, 673, 892, 911A, 1656, 8011; BAS 180/1, 183/4, 390; BS CC937, CE 012, HON-T, 541B, 544B, 836A-2, 903D, 929, 932A, 932E, 932F, 937, 938-1; CMSI 3041; IARM 77B, 80B, 84A, 92A, 9250; KMS LCSON-001; SRM C1101, C1253, 15E, 55D, 63B, 124D, 158A, 498, 1253A, 1413, 3101A, 3113, 3126A, 3132, 3139A, 3150; 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 — 501-676; CMSI 3041; BS CC937, CE 012, HON-T, 544B, 836A-2, 929, 932A, 932E, 937, 938-1; KMS LCSON-001; SRM C1253; 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 936 is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Source: The bar stock for this CRM was supplied by Lokey Metals, Fort Worth, TX.

Form: This CRM is machined in the form of a disc, approximately 50 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 936-022316. 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 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 30:1992 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, 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 February 23, 2016.

Beau R. Brammer