

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 937C

Certified Reference Material for Bronze CDA Grade 937- UNS Number C93700

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
As	0.0112	0.0009		P	0.0009	0.0004
Co	0.0006	0.0002		Pb	9.15	0.07
Cu	80.0	0.3		S	0.025	0.002
Fe	0.0033	0.0005		Sb	0.55	0.01
Ni	0.26	0.01		Sn	9.99	0.05
O	0.0060	0.0004		Zn	0.196	0.008

	Reference Value ¹	Estimate of Uncertainty ²	Reference Values⁴	Reference Value ¹	Estimate of Uncertainty ²
C	0.0015	0.0003			

Informational Values^{3,5}

Ag (0.015)	Al (0.0008)	Bi (0.018)	Cd (0.0002)	Cr (0.00004)
Mn (0.0007)	N (0.0002)	Se (0.0008)	Si (0.002)	Te (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 Au, In, Mo, and Ti 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.

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* Code for method Certified values listed as weight percent

Analysis	*	As	*	Co	*	Cu	*	Fe	*	Ni	*	O	*	P	*	Pb
1	5	0.008567	12	0.00045	16	[79.48]	5	0.0021	12	0.2200	2	0.0051	4	0.0006	4	9.043333
2	3	0.00975	4	0.000567	14	79.76667	12	0.0024	4	0.234067	2	0.005667	5	0.000633	5	9.089333
3	9	0.010233	5	0.00059	4	79.82667	4	0.002933	5	0.2350	2	0.005753	12	0.00084	4	9.0932
4	4	0.010567	5	0.0006	4	79.86667	4	0.003333	5	0.240	2	0.006017	7	0.001157	4	9.093333
5	4	0.010667	5	0.000677	4	79.87	5	0.0035	4	0.25	2	0.0061	4	0.001317	4	9.102
6	5	0.011667	5	0.000687	16	[80.09333]	4	0.00625	5	0.250233	2	0.0062			14	9.133333
7	4	0.011833	4	0.0010	13	80.20267	5	0.006367	4	0.252333	2	0.006203			10	9.196667
8	5	0.012067	5	0.0011	4	80.23447			4	0.2528	2	0.00636			4	9.216667
9	12	0.0122	14	0.001567	16	[80.71]			4	0.2564	2	0.00638				
10	5	0.012833	3	0.00385	4	80.73333			14	0.261333	2	0.0084				
11									4	0.268						
12									8	0.272333						
13									4	0.28						
14									3	0.287						
Average		0.01124		0.000634		80.018		0.00331		0.2635		0.00605		0.00086		9.150
Std dev		0.00052		0.000051		0.052		0.00036		0.0048		0.00021		0.00016		0.066
H		0.00074		0.000276		0.441346		0.000456		0.004025		0.000572		0.000299		0.058013
U ₁		0.00090		0.00028		0.44		0.00058		0.0063		0.00061		0.00034		0.088
t-statistic		2.26		2.26		2.26		2.45		2.16		2.26		2.78		2.36
U ₂		0.0020		0.00063		1.010		0.0014		0.014		0.0014		0.00095		0.21
U ₃		0.00065		0.00020		0.32		0.00054		0.0036		0.00044		0.00042		0.074
Certified		0.0112		0.0006		80.0		0.0033		0.26		0.0060		0.0009		9.15
Uncertainty		0.0009		0.0002		0.3		0.0005		0.01		0.0004		0.0004		0.07
Tolerance		0.0020		0.0006		1.0		0.0014		0.03		0.0014		0.0009		0.21

Analysis	*	S	*	Sb	*	Sn	*	Zn
1	1	0.021467	4	0.513	4	9.824333	5	0.181467
2	1	0.021633	5	0.5211	4	9.90	5	0.183
3	1	0.023533	4	0.54	14	9.95	3	0.186
4	1	0.02372	4	0.540167	4	9.987	4	0.188633
5	1	0.0238	4	0.542333	4	10.01	4	0.188667
6	12	0.0255	4	0.555667	4	10.03333	4	0.189
7	1	0.026667	4	0.5594	4	10.03667	12	0.1900
8	1	0.027067	4	0.560	4	10.08053	4	0.19
9	4	0.02735	4	0.5666	3	10.1	4	0.1934
10	1	0.029433	4	0.566667	4	10.1012	4	0.197333
11	1	0.0321	5	0.573367			4	0.197867
12			12	0.6000			4	0.20
13							14	0.207667
14							10	0.216667
Average		0.0252		0.5533		9.992		0.1964
Std dev		0.0010		0.0059		0.043		0.0041
H		0.001074		0.006577		0.062625		0.003346
U ₁		0.0015		0.0088		0.076		0.0053
t-statistic		2.23		2.20		2.26		2.16
U ₂		0.0033		0.019		0.17		0.011
U ₃		0.00099		0.0056		0.054		0.0030
Certified		0.025		0.55		9.99		0.196
Uncertainty		0.002		0.01		0.05		0.008
Tolerance		0.005		0.04		0.17		0.0020

BS 937C * Code for method Reference values listed as weight percent

Analysis	*	C
1	1	0.0004
2	1	0.000667
3	3	0.0013
4	1	0.0016
5	1	0.002667
6	1	0.002923
7	1	0.006633
8	1	0.0074
9	1	0.0077
Average		0.00154
Std dev		0.00013
H		0.000353
U ₁		0.00038
t-statistic		2.31
U ₂		0.00087
U ₃		0.00029
Reference		0.0015
Uncertainty		0.0003
Tolerance		0.0009

BS 937C * Code for method Informational values listed as weight percent

Analysis	*	Ag	*	Al	*	Bi	*	Cd	*	Cr	*	Mn	*	N	*	Se
1	5	0.0133	12	0.000065	5	0.0171	5	0.00006	12	0.000030	12	0.0000025	2	0.000198	5	0.00036
2	5	0.0143	4	0.000567	12	0.0172	5	0.00019	5	0.000044	4	0.0005333	2	0.0003	5	0.00062
3	12	0.0150	14	0.0010	4	0.0185	12	0.00020			3	0.001			12	0.00130
4	4	0.0160	3	0.00175	5	0.0189					4	0.0013				
5																
6																
Average		0.01		0.0008		0.02		0.000151		0.0000372		0.0007		0.00025		0.0008
Std dev		0.17		0.0027		0.21		0.000085		0.0000031		0.0019		0.00032		0.0026
H		0.000704		0.000293		0.000961		0.000206		0.000175		0.000283		0.000225		0.000293
U ₁		0.17		0.0027		0.21		0.00022		0.00018		0.0020		0.00039		0.0026
t-statistic		3.18		3.18		3.18		4.30		12.71		3.18		12.71		4.30
U ₂		0.55		0.0086		0.68		0.00096		0.0022		0.0062		0.0050		0.011
U ₃		0.27		0.0043		0.34		0.00055		0.0016		0.0031		0.0035		0.0064
(Informational)		(0.015)		(0.0008)		(0.018)		(0.0002)		(0.00004)		(0.0007)		(0.0002)		(0.0008)

Analysis	*	Si	*	Te
1		0.00015	5	0.00011
2		0.00036	5	0.00068
3		0.00042	12	0.00070
4		0.0021		
5		0.0027		
6		0.0066		
Average		0.002		0.0005
Std dev		0.010		0.0011
H		0.000384		0.00026
U ₁		0.010		0.0011
t-statistic		2.57		4.30
U ₂		0.026		0.0049
U ₃		0.011		0.0028
		(0.002)		(0.0005)

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.

BS 937C

* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	* Au	* In	* Mo	* Ti
1	12 1.5	12 12	12 0.20	12 0.060

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
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
Evans Analytical Group	Liverpool, NY	A2LA	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
Exova	Glendale Heights, IL	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	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 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: 32XALB5H, 32XLB10; 501-149, 501-676, 501-953, 501-991, 502-257, 502-403, 502-494, 502-991; AR 147, 614A, 645, 657, 662, 673, 892, 911A, 1656, 8011; BAS 180/1, 183/4, 207/2, 390; BS CE 012, HON-T, 903D, 905A-3, 929, 932, 932E, 932F, 937, 938-1; CKD 321, 322; CMIS 3041; IARM 80B, 92A, 250A, 9250; KMS LCSON-001; SRM C1101, 15E, 55D, 63B, 124D, 158A, 498, 1253A, 1413, 3113, 3126A, 3132, 3136; 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; BS CE 012, HON-T, 905A-3, 932, 932E, 937, 938-1; CKD 321, 322; CMSI 3041; KMS LCSON-001; 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 937C is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Source: The bar stock for this CRM was produced by National Bronze & Metals, Inc., Houston, Texas.

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 937C-020813. 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.

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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 February 08, 2016.

Beau R. Brammer