

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 655B

Certified Reference Material for Silicon Bronze - UNS Number C65500

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values ³
As	0.0004	0.0002	
C	0.0012	0.0002	
Cr	0.0006	0.0002	
Cu	95.7	0.4	
Fe	0.042	0.001	
Mn	0.928	0.006	
Ni	0.0043	0.0002	
P	0.0047	0.0003	
Pb	0.0205	0.0006	
S	0.0010	0.0002	
Sb	0.0002	0.0001	
Si	3.25	0.02	
Sn	0.0053	0.0003	
Zn	0.0248	0.0008	

Informational Values^{3,4}

Al (<0.005)	Be (<0.0005)	Co (<0.005)	Mg (<0.0005)	N (<0.0005)
O (<0.0005)	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 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.

⁴ Values in parentheses are not certified and are provided for information only.

Trace element information values for Ag, B, Bi, Nb, Se, Te, Ti, and V are shown on page 3.

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.

Analysis	*	As	*	C	*	Cr	*	Cu	*	Fe	*	Mn	*	Ni	*	P
1	4	0.00037	1	0.0006	5	0.00040	6	95.1	4	0.0390	5	0.893	3	0.0037	7	0.0036
2	5	0.00040	1	0.0007	5	0.00040	4	95.5	5	0.0390	4	0.913	5	0.0039	5	0.0037
3	5	0.00040	1	0.0010	14	0.00050	3	95.5	4	0.0394	4	0.913	5	0.0039	3	0.0040
4	5	0.00044	1	0.0010	5	0.00051	4	95.6	5	0.0405	4	0.925	4	0.0040	5	0.0043
5	5	0.00050	1	0.0013	5	0.00070	4	95.7	3	0.0416	7	0.926	14	0.0040	5	0.0043
6	5	0.00050	1	0.0017	4	0.00070	5	95.7	4	0.0417	14	0.927	4	0.0040	3	0.0045
7			3	0.0018	5	0.00110	4	95.7	4	0.0423	4	0.927	5	0.0043	4	0.0045
8			1	0.0018			14	95.7	5	0.0435	3	0.932	8	0.0043	4	0.0045
9							3	95.8	7	0.0440	3	0.934	4	0.0045	3	0.0053
10							6	95.8	5	0.0446	3	0.936	5	0.0046	5	0.0054
11							10	95.8	3	0.0478	4	0.937	5	0.0046	4	0.0058
12							13	95.9	3	0.0478	5	0.939	3	0.0047	3	0.0058
13											4	0.943	5	0.0047		
14											3	0.951	3	0.0053		
Average		0.000415		0.00119		0.000567		95.70		0.0417		0.9280		0.00428		0.00471
Std dev		0.000068		0.00012		0.000091		0.11		0.0010		0.0055		0.00021		0.00028
H		0.00018		0.00024		0.00019		0.58		0.0011		0.008		0.00038		0.00039
U ₁		0.00019		0.00027		0.00021		0.59		0.0015		0.010		0.00043		0.00048
t-statistic		2.57		2.36		2.45		2.20		2.20		2.16		2.16		2.20
U ₂		0.00049		0.00063		0.00052		1.30		0.0033		0.022		0.00093		0.0011
U ₃		0.00020		0.00022		0.00020		0.38		0.0010		0.0058		0.00025		0.00031
Certified		0.0004		0.0012		0.0006		95.7		0.042		0.928		0.0043		0.0047
Uncertainty		0.0002		0.0002		0.0002		0.4		0.001		0.006		0.0002		0.0003
Tolerance		0.0004		0.0006		0.0005		1.3		0.003		0.022		0.0009		0.0011

Analysis	*	Pb	*	S	*	Sb	*	Si	*	Sn	*	Zn
1	5	0.0185	3	0.00050	5	0.00015	6	3.19	14	0.0046	5	0.0210
2	4	0.0193	1	0.00060	5	0.00016	14	3.21	5	0.0047	4	0.0214
3	3	0.0194	1	0.00070	5	0.00018	6	3.21	5	0.0048	14	0.0222
4	9	0.0201	1	0.00088	5	0.00020	5	3.22	5	0.0050	4	0.0230
5	3	0.0208	1	0.00095	5	0.00020	4	3.24	4	0.0050	4	0.0235
6	10	0.0210	1	0.00100	4	0.00100	4	3.24	5	0.0052	5	0.0238
7	5	0.0211	1	0.00100			3	3.24	3	0.0056	5	0.0244
8	4	0.0212	1	0.00100			3	3.24	3	0.0056	5	0.0250
9	4	0.0213	1	0.00100			10	3.25	4	0.0057	8	0.0265
10	14	0.0219	1	0.00130			5	3.26	5	0.0057	4	0.0270
11	3	0.0222	5	0.00130			4	3.28	3	0.0061		
12	4	0.0228	3	0.00143			6	3.28				
13							4	3.30				
14							3	3.30				
15							3	3.34				
Average		0.02054		0.000957		0.000171		3.249		0.00525		0.02477
Std dev		0.00065		0.000089		0.000039		0.014		0.00025		0.00064
H		0.0008		0.00022		0.00015		0.023		0.00041		0.0008
U ₁		0.0010		0.00024		0.00015		0.027		0.00048		0.0011
t-statistic		2.20		2.20		2.78		2.14		2.23		2.26
U ₂		0.0022		0.00053		0.00042		0.058		0.0011		0.0024
U ₃		0.00064		0.00015		0.00019		0.015		0.00032		0.00076
Certified		0.0205		0.0010		0.0002		3.25		0.0053		0.0248
Uncertainty		0.0006		0.0002		0.0001		0.02		0.0003		0.0008
Tolerance		0.0022		0.0005		0.0002		0.06		0.0011		0.0024

Analysis	*	Al	*	Be	*	Co	*	Mg	*	N	*	O	*	Zr
1	5	0.0006	4	0.000010	4	0.0015	5	0.00010	2	0.0002	2	0.0002	3	0.00010
2	4	0.0009	14	0.00010	5	0.0016	3	0.00010	2	0.0004	2	0.0002	4	0.00020
3	4	0.0010	3	0.00010	3	0.0025	3	0.00020			2	0.0005		
4	3	0.0011			3	0.0044					2	0.0005		
5	5	0.0012									2	0.0008		
6	14	0.0014												
Average		0.00094		0.000058		0.00258		0.000126		0.00028		0.00043		0.000150
Std dev		0.00014		0.000041		0.00032		0.000069		0.00013		0.00011		0.000086
H		0.00022		0.00012		0.00031		0.00014		0.00016		0.00018		0.00014
U ₁		0.00026		0.00013		0.00045		0.00016		0.00021		0.00021		0.00017
t-statistic		2.57		4.30		3.18		4.30		12.71		2.78		12.71
U ₂		0.00067		0.00057		0.0014		0.00067		0.0026		0.00058		0.0021
U ₃		0.00028		0.00033		0.00071		0.00039		0.00180		0.00026		0.00150
(Information)		(<0.005)		(<0.0005)		(<0.005)		(<0.0005)		(<0.0005)		(<0.0005)		(<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. U₁ is the combined uncertainty from homogeneity and labs. U₂ is U₁ times 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.

Analysis	*	Ag	*	B	*	Bi	*	Nb	*	Se	*	Te	*	Ti	*	V
1	5	15	4	4	5	0.4	3	12	5	2.6	5	0.6	4	1.3	5	0.1
2					3	14							3	6		

Analytical Method Codes:

- | | | | | | |
|---|-------------------------|----|-------------------------|----|------------------------|
| 1 | Combustion (ASTM E1019) | 7 | Photometric | 13 | Titrimetric |
| 2 | Fusion (ASTM E 1019) | 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 | | |
| 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>
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Andrew S. McCreath & Son, Inc.	Harrisburg, PA	A2LA	17025
APL, Inc	Milwaukee, WI	A2LA	17025
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Dirats Laboratories	Westfield, MA	ACCLASS	17025
Exova	Glendale Heights, IL	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
NSL Analytical	Cleveland, OH	ACCLASS	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 of the certified portion of the lot in accordance with ASTM Standard Practice E 1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025. Methods of analysis used were those listed on page 3.

Traceability: The following Certified Reference Materials were used to validate the analytical data listed on page 2 — 31XWSB2, 32XLB10, 32XLB12, 32XSEB5, 32XSEB7, 33XGM5, 34XNS3; 501-147, 501-644, 501-646, 501-673, 502-102, 502-193, 502-403; BAS 183/4, 304/1, 390; BS 110A, 642A, 655, 875, 954A, CC995; CS1-CS5; CSB 1566, 1567; IARM 70B, 80B, 82A, 82B, 83A, 86B, 88A, 92B, 94A, 150A, 151B, 190A; SRM 55D, 158A, 164A, 494, 1253A, 3105A, 3113, 3131A, 3136, 3168A, 3169.

Homogeneity: This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the following Reference Materials — BS 642A, 655, 876, 954A, CC995; CSB 1566, 1567; IARM 82B.

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 655B 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 LDM B.V., Drunen, The Netherlands

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 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 you use for production specimens. Avoid overheating the sample during surface preparation.

Certificate Number: The unique identification number for this certificate of analysis is 655B-032113. You may obtain information on revisions of certificates from the internet at www.brammerstandard.com.

Safety Notice: A Material Safety Data Sheet (MSDS) 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

- E 826 Standard Practice for Testing Homogeneity of a Metal Lot or Batch in Solid Form by Spark Atomic Emission Spectrometry
- E 1019 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
- E 1806 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, 1916 Race Street, Philadelphia, PA, 19103.

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 21, 2013.

Beau R. Brammer