

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 18150

Certified Reference Material for Copper Alloy - UNS Number C18150

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0009	0.0003			
C	0.0009	0.0003			
Cr	0.74	0.01			
Cu	[99.1]	0.4			
Fe	0.0047	0.0007			
Mn	0.0010	0.0002			
Ni	0.0010	0.0003			
P	0.0037	0.0004			
Pb	0.0005	0.0002			
S	0.0007	0.0002			
Si	0.019	0.001			
Sn	0.0097	0.0005			
Zn	0.0006	0.0002			
Zr	0.113	0.002			

Informational Values^{3,4}

As (0.0004)

Co (0.0002)

O (0.0006)

Sb (0.0001)

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, Ca, Cd, Cl, Ga, In, K, Mg, N, Na, Nb, Rh, Se, Ti, V, and W 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.

BS 18150

* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	C	*	Cr	*	Cu	*	Fe	*	Mn	*	Ni	*	P
1	12	0.0008	1	0.00058	4	0.604333	16	98.965	4	0.0035	5	0.00082	5	0.0008	12	0.0026
2	5	0.0008	1	0.000613	4	0.6379	13	98.98833	12	0.0044	12	0.0009	5	0.00081	4	0.003067
3	5	0.0009	1	0.000697	10	0.706667	16	99.04	5	0.0046	4	0.000967	5	0.000813	4	0.003233
4	5	0.001023	1	0.000825	3	0.726	10	99.05667	5	0.005233	5	0.0010	12	0.00093	7	0.00350
5	5	0.001133	1	0.000867	4	0.7553	16	99.07333	5	0.005533	5	0.0010	5	0.0010	4	0.003513
6	5	0.001343	1	0.0020	4	0.768667	10	99.13	5	0.0056	4	0.0010	4	0.00104	4	0.003833
7	3	0.001675	1	0.002867	10	0.783333	16	99.198	4	0.005867	8	0.001017	8	0.001073	5	0.0041
8	4	0.001767			4	0.79	4	99.21667			4	0.00102	4	0.001733	5	0.0043
9					4	0.816	6	99.36			5	0.001233			3	0.004775
10							16	99.43								
Average		0.00091		0.00095		0.742		99.053		0.00472		0.000995		0.001020		0.00375
Std dev		0.00010		0.00013		0.011		0.092		0.00058		0.000090		0.000090		0.00020
H		0.00028		0.00028		0.008		0.49		0.00049		0.00029		0.00029		0.00045
U ₁		0.00030		0.00031		0.013		0.50		0.00075		0.00030		0.00030		0.00049
t-statistic		2.36		2.36		2.31		2.26		2.45		2.31		2.36		2.31
U ₂		0.00071		0.00074		0.030		1.13		0.0018		0.00070		0.00072		0.0011
U ₃		0.00025		0.00026		0.010		0.36		0.00070		0.00023		0.00025		0.00038
Certified		0.0009		0.0009		0.74		[99.1]		0.0047		0.0010		0.0010		0.0037
Uncertainty		0.0003		0.0003		0.01		0.4		0.0007		0.0002		0.0003		0.0004
Tolerance		0.0007		0.0007		0.03		1.1		0.0018		0.0007		0.0007		0.0011

Analysis	*	Pb [#]	*	S	*	Si	*	Sn	*	Zn	*	Zr
1	12	0.00025	1	0.000467	5	0.0130	4	0.008333	5	0.000313	10	0.106667
2	5	0.0003	1	0.000567	5	0.0149	5	0.0085	12	0.0004	4	0.11
3	5	0.00031	1	0.0006	10	0.0174	3	0.00965	4	0.0006	4	0.1108
4	5	0.0004	1	0.000623	3	0.01785	5	0.009767	5	0.000633	4	0.112
5	5	0.0004	1	0.000793	5	0.017867	12	0.01	5	0.000687	4	0.1137
6	5	0.000417	1	0.0008	7	0.018333	4	0.010133	5	0.0007	7	0.114
7	5	0.00042	1	0.00084	4	0.019433	5	0.010267	8	0.001157	3	0.1155
8	3	0.000825	1	0.000847	4	0.0210	5	0.0108			4	0.117333
9	4	0.0011	1	0.0009	12	0.022	5	0.011367			5	0.119567
10			3	0.00115	4	0.023667					4	0.123
11			12	0.0012	4	0.024167					5	0.126867
Average		0.000491		0.000684		0.0193		0.00969		0.000601		0.1127
Std dev		0.000045		0.000050		0.0012		0.00026		0.000057		0.0028
H		0.00024		0.00026		0.0009		0.00066		0.00025		0.0023
U ₁		0.00024		0.00027		0.0015		0.00071		0.00026		0.0036
t-statistic		2.31		2.23		2.23		2.31		2.45		2.23
U ₂		0.00056		0.00059		0.0034		0.0016		0.00063		0.0080
U ₃		0.00019		0.00018		0.0010		0.00054		0.00024		0.0024
Certified		0.0005		0.0007		0.019		0.0097		0.0006		0.113
Uncertainty		0.0002		0.0002		0.001		0.0005		0.0002		0.002
Tolerance		0.0005		0.0006		0.003		0.0016		0.0006		0.008

Unweighted mean and standard deviation were used to calculate Phosphorus. The weighted mean is 0.000394 and standard deviation is 0.000037. The weighted certified value is 0.0004 with an uncertainty of 0.0002 and tolerance of 0.0004.

BS 18150 * Code for method Informational values listed as weight percent

Analysis	* As	* Co	* O	* Sb
1	5 0.000051	5 0.000173	2 0.0003	12 0.000038
2	5 0.0000667	5 0.00018	2 0.000367	5 0.0000467
3	12 0.000076	12 0.00019	2 0.00063	5 0.00005767
4	5 0.0001	5 0.0002	2 0.000667	5 0.00006166
5	5 0.00016	5 0.0002	2 0.001281	5 0.0001
6	4 0.001			4 0.0010
7	3 0.001375			4 0.002
8				3 0.0086
Average	0.000404	0.000189	0.000649	0.000123
Std dev	0.000036	0.000011	0.000096	0.000025
H	0.00023	0.00019	0.00026	0.00018
U ₁	0.00023	0.00019	0.00027	0.00018
t-statistic	2.45	2.78	2.78	2.36
U ₂	0.00057	0.00054	0.00076	0.00043
U ₃	0.00021	0.00024	0.00034	0.00015
(Informational)	(0.0004)	(0.0002)	(0.0006)	(0.0001)

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.

BS 18150 * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	* Ag	* B	* Bi	* Ca	* Cd	* Cl	* Ga	* In	* K	* Mg
1	12 9.6	12 0.12	12 0.14	12 0.41	5 1.3	12 0.003	12 0.34	12 0.30	12 0.24	12 0.75
2	5 10		5 0.16	4 4.2	5 1.3		5 0.53			5 0.85
3	5 10		5 0.16		5 1.3		5 0.53			5 0.85
4	5 10		5 0.16		5 2		5 0.58			5 0.86
5	5 15									3 9.7

Analysis	* N	* Na	* Nb	* Rh	* Se	* Ti	* V	* W
1	2 0.987	12 0.27	12 0.61	5 18	5 1.0	12 0.071	12 0.16	5 3
2	2 1		5 1.0		5 1.0	5 3		
3	2 1		5 1.2		5 1.0			
4	2 1.04		5 1.4		5 32			
5	2 1.06							
6	2 2							

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	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
Evans Analytical Group	Liverpool, NY	A2LA	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
Dirats Laboratories	Westfield, MA	ACCLASS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Exova	Glendale Heights, IL	A2LA	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	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 E 1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025. Methods of analysis used are those listed on pages 2-3.

Traceability: The following Certified Reference Materials were used to validate the analytical data listed on page 2-3 — 37x226A; 501-147, 501-502, 501-503, 501-550, 501-646, 501-676, 501-952, 501-953, 501-991, 502-102, 502-257, 502-403, 502-494; AR 645, 662, 892; BAS 179/2, 180/1, 183/4, 207/1, 390; BS CCR1, 172BE-1, 642B, 706, 706B; ECRM 196-2; IARM 72B, 77B, 80B, 82B, 158B, 158C; IMZ 1.7/1; SRM C1100, C1121, 124D, 158A, 498, 1253, 1253A, 2168, 3101A, 3102A, 3103A, 3113, 3126A, 3128, 3132, 3150, 3161A, 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 — 501-676; BS CCR1, 172BE-1, 642B, 706, 706B; ECRM 196-2; IARM 82B; IMZ 1.7/1; SRM C1121, C1253, 2168.

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 18150 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.; Hosuton, 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 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 18150-090514. 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 September 05, 2014.

Beau R. Brammer