Brammer Standard Company, Inc.

Certificate of Analysis

BS 464B

Certified Reference Material for Copper Alloy 464 - UNS Number C46400

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
As	**0.0005**	0.0002	**Pb**	**0.054**	0.007
Cu	**60.5**	0.2	**S**	**0.0005**	0.0002
Fe	**0.050**	0.005	**Si**	**0.011**	0.001
Ni	**0.0092**	0.0009	**Sn**	**0.69**	0.02
O	**0.0013**	0.0005	**Zn**	**38.7**	0.2

Informational Values[3,4]

Al (0.004)	C (0.009)	Co (0.0007)	Cr (0.001)	Mg (0.0000002)
Mn (0.09)	N (0.0005)	P (0.002)	Sb (0.001)	Zr (0.000002)

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. Values in brackets are reported by difference.

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

Trace element information values for Ag, Au, B, Bi, Ca, Cd, Cl, Ga, Ge, In, Mo, Na, Pd, Se, Te, Ti, Tl, V, and W are shown on page 3.

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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BS 464B * Code for method Certified values listed as weight percent

Analysis	*	As	*	Cu	*	Fe	*	Ni	*	O	*	Pb	*	S	*	Si	*	Sn	*	Zn
1	5	0.0001	10	60.2632	4	0.04006667	4	0.006	1	0.00054	4	0.0400	1	0.0001	10	0.0060333	4	0.63007	4	38.460
2	3	0.0003	3	60.27	14	0.04023333	12	0.0076364	2	0.00063333333	9	0.0406	1	0.00017	4	0.0093	14	0.633	4	38.49333333333
3	5	0.00059	10	60.3333	4	0.04193333	12	0.0078	2	0.00076	17	0.046	16	0.00038667	12	0.0097455	4	0.66	4	38.53666666667
4	12	0.0006933	16	[60.35]	12	0.04525	12	0.0078167	2	0.00087366667	4	0.0461	3	0.0004	4	0.0099333	4	0.67333	4	38.68176666667
5	5	0.0007333	4	60.3727	3	0.045925	10	0.0083333	4	0.001	12	0.0475	4	0.0005	4	0.0100667	4	0.67433	10	38.6933
6	12	0.0007463	13	60.3967	12	0.04675	12	0.0083629	2	0.00103333333	12	0.0479	12	0.00050155	12	0.0102667	10	0.675	4	38.7
7	12	0.0007485	6	60.5233	4	0.047	12	0.0085726	12	0.00131	12	0.0488	12	0.00050809	3	0.0103667	4	0.686	3	38.73
8	12	0.0007855	14	60.5333	12	0.047275	12	0.0086442	2	0.0016	12	0.051	12	0.0005174	12	0.0105	4	0.69557	10	38.74333333333
9	3	0.001	16	[60.55]	12	0.04773333	4	0.0089333	12	0.0018424	12	0.0538	12	0.00068667	12	0.0106667	3	0.7	14	38.76666666667
10			4	60.6	12	0.048825	3	0.009125	12	0.002132075	12	0.0546667			14	0.0113667	4	0.71023	16	38.81966666667
11			16	[60.62]	3	0.05033333	4	0.0091333	2	0.00236666667	3	0.055			3	0.0127	17	0.72333	3	38.945
12			17	60.7733	10	0.05273333	4	0.0091333			12	0.0551			4	0.013	4	0.73467		
13					4	0.0528	14	0.0094			12	0.0573			5	0.0141667	3	0.73967		
14					3	0.054	3	0.0101667			3	0.057725			10	0.01628	10	0.74736		
15					4	0.05426667	5	0.0102667			3	0.0580								
16					5	0.0545	5	0.0103667			10	0.05826								
17					4	0.055	4	0.012			4	0.0591333								
18					17	0.056					4	0.0601667								
19					10	0.05766					10	0.0601667								
20											4	0.062								
21											12	0.063075								
22											4	0.06375								
23											12	0.06395								
24											5	0.0643								
25											12	0.066825								
Average		0.000497		60.495		0.0499		0.00916		0.001281		0.0541		0.0004986		0.011028		0.688		38.69
Std Dev		0.000074		0.044		0.0015		0.00036		0.000095		0.0017		0.0000063		0.000085		0.018		0.18
H		0.00029		0.29		0.0017		0.00076		0.00038		0.0018		0.00029		0.00083		0.008		0.19
U_1		0.00030		0.29		0.0023		0.00085		0.00039		0.0025		0.00029		0.00083		0.020		0.26
t-statistic		2.31		2.20		2.10		2.12		2.23		2.06		2.31		2.16		2.16		2.23
U_2		0.00069		0.64		0.0048		0.0018		0.00086		0.0051		0.00067		0.0018		0.043		0.58
U_3		0.00023		0.18		0.0011		0.00044		0.00026		0.0010		0.00022		0.00048		0.012		0.18
Certified		**0.0005**		**60.5**		**0.050**		**0.0092**		**0.0013**		**0.054**		**0.0005**		**0.011**		**0.69**		**38.7**
Uncertainty		0.0002		0.2		0.005		0.0009		0.0005		0.007		0.0002		0.001		0.02		0.2
Tolerance		0.0005		0.6		0.015		0.0027		0.0011		0.021		0.0005		0.003		0.06		0.6

BS 464B * Code for method Informational values listed as weight percent

Analysis	*	Al	*	C	*	Co	*	Cr	*	Mg	*	Mn	*	N	*	P	*	Sb	*	Zr
1	12	0.0016667	1	0.00063	12	0.0000563	12	0.000121	12	0.000000213	12	0.0556	2	0.0002	12	0.0006234	5	0.0002	12	0.0000001999
2	12	0.0023585	1	0.00074	12	0.0000670	12	0.00015	12	0.000000217	12	0.0564333	2	0.00026667	12	0.0006668	12	0.00038	12	0.0000022
3	12	0.0024922	1	0.001	12	0.0000720	3	0.003	12	0.000000270	12	0.0696667	12	0.00036078	12	0.0006784	5	0.00046	12	0.000002575
4	12	0.0024979	1	0.00103	12	0.0000728					4	0.074	12	0.00048927	5	0.0013667	12	0.00049		
5	4	0.0040667	12	0.00361	3	0.003					10	0.09328	12	0.0005725	12	0.0018	12	0.0005		
6	4	0.006	12	0.00469							4	0.098	4	0.001	4	0.0026333	12	0.00052		
7	3	0.007	4	0.005							10	0.0997667			3	0.004	12	0.00054		
8			12	0.00571							17	0.100			4	0.004	12	0.00058		
9			3	0.05433							4	0.1012333			3	0.004175	5	0.0006		
10											4	0.1016667			4	0.0042667	12	0.0006		
11											3	0.102					9	0.00163		
12																	4	0.002		
13																	3	0.00255		
14																	4	0.0039		
Average		0.004		0.009		0.0007		0.0011		0.000000200		0.09		0.00048		0.002		0.0011		0.0000015
Std Dev		0.023		0.062		0.0015		0.0049		0.000000026		0.45		0.00074		0.010		0.0022		0.0000010
H		0.001		0.00076		0.0003		0.0004		0.00025		0.00		0.00029		0.000		0.0004		0.00018
U_1		0.023		0.062		0.0015		0.0050		0.00025		0.45		0.00080		0.010		0.0022		0.00018
t-statistic		2.45		2.31		2.78		4.30		4.30		2.23		2.57		2.26		2.16		4.30
U_2		0.057		0.14		0.0042		0.021		0.0011		1.00		0.0021		0.023		0.0048		0.00079
U_3		0.022		0.048		0.0019		0.012		0.00061		0.30		0.00084		0.0074		0.0013		0.00045
Informational		(0.004)		(0.009)		(0.0007)		(0.001)		(0.0000002)		(0.09)		(0.0005)		(0.002)		(0.001)		(0.000002)

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. 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:

$$C_L = \sqrt{S_L^2 + U_L^2} \qquad W_L = \frac{1}{C_L^2} \qquad A = \frac{\sum_{i=1}^{n} W_L M_L}{\sum_{i=1}^{n} W_L} \qquad S = \frac{1}{\sqrt{\sum_{i=1}^{n} W_L}} \qquad U_1 = \sqrt{H^2 + S^2} \qquad U_2 = t \times U_1 \qquad U_3 = \frac{U_2}{\sqrt{n}}$$

*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.

BS 464B * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ag	*	Au	*	B	*	Bi	*	Ca	*	Cd	*	Cl	*	Ga	*	Ge	*	In
1	12	0.10	12	0.04	12	0.02	12	0.95	12	0.00468	12	1.6	12	0.006	12	0.22	12	0.03	12	1.7
2	12	0.11	12	0.05	12	0.02	12	1.1	12	0.0061	12	1.8	12	0.01	12	0.22	12	0.04	12	1.8
3	12	0.11	12	0.05	12	0.03	12	1.2	12	0.0066	12	2.3	12	0.02	12	0.24	12	0.06	12	2.2
4	4	30					4	40			3	10								
5	3	30																		

Analysis	*	Mo	*	Na	*	Pd	*	Se	*	Te	*	Ti	*	Tl	*	V	*	W
1	12	0.02	12	0.008	12	0.44	12	1.2	12	3.085	12	0.001	12	0.73	12	0.01	12	0.007
2	12	0.03	12	0.008	12	0.49	12	1.2	12	3.098	12	0.002	12	0.9	12	0.02	12	0.008
3	12	0.21	12	0.008	12	0.66	12	1.3	12	3.186	12	0.004	12	0.99	12	0.02	12	0.01
4									12	3.2								
5									12	3.242								
6									12	3.5								
7									12	3.83								
8									12	3.899								
9									12	4.1								

Analytical Method Codes:

1 Combustion (ASTM E1019)
2 Fusion (ASTM E1019)
3 Spark Atomic Emission
4 ICP Atomic Emission
5 ICP Mass Spectrometry
6 Gravimetric
7 Photometric
8 Flame Atomic Absorption
9 GF Atomic Absorption
10 X-Ray Fluorescence
11 GD Atomic Emission
12 GD Mass Spectrometry
13 Titrimetric
14 DCP Atomic Emission
15 HG Atomic Fluorescence
16 Difference
17 PIXE

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
Dirats Laboratories	Westfield,MA	ANAB	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Exova	Glendale Heights, Il	A2LA	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
TUV Rheinland Pvt. Ltd.	Bangalore, India	NABL	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025

A2LA = American Association for Laboratory Accreditation
ANAB = ANSI-ASQ National Accreditation Board
NABL = National Accreditation Board for Testing and Calibration Laboratories
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: 31XB15H, 39X17866AC, 39XCT6; AR 147, 148, 673, 892, 1652, 1653; BAM 222, 361; BAS 179/2, 183/4, 390; BS 110B, 360A, 360B, 405C, 464A, 482, 510B, 630C, 675A, 675B, 705C, 903D, 929; IARM 74A, 74B, 80B, 83A, 83B, 226A; LECO 501-147, 501-402, 501-992, 502-416, 502-874; SRM C1107, 19F, 37D, 55D, 62, 62D, 158A, 164A, 400, 459, 1106, 1108, 1112, 1113, 1114, 1413.

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 — BAM 361; BS 110B, 360A, 360B, 464A, 482, 675A, 675B, 903D, 929, 14500; SRM 1106, 1108.

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 464B 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 Non-Ferrous Metal Works (SA) (Pty) Ltd; Kwa-Zulu Natal, South Africa

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.

> 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 464B-082917. 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) 440-9396Web: 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 Standard 17034 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 30:2015 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 35:2006 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 August 29, 2017.

Beau R. Brammer

President