Brammer Standard Company, Inc.

Certificate of Analysis
BS 14500A

Certified Reference Material for Tellurium Copper Alloy - UNS Number C14500

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Cu	**99.6**	0.3	**S**	**0.035**	0.008
Ni	**0.0026**	0.0006	**Sn**	**0.0028**	0.0007
O	**0.0017**	0.0005	**Te**	**0.51**	0.02
P	**0.010**	0.001	**Zn**	**0.0053**	0.0007
Pb	**0.0031**	0.0007			

Informational Values[3,4]

Al (0.0007)	C (0.003)	Ca (0.00004)	Co (0.0005)	Fe (0.001)
Mg (0.00006)	Mn (0.0004)	N (0.0006)	Sb (0.005)	Si (0.002)
Zr (0.001)				

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, As, Au, B, Bi, Cd, Cl, Cr, Ga, Ge, In, Mo, Nb, Ru, Se, Ti, 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.

BS 14500A   * Code for method   Certified values listed as weight percent

Analysis	*	Cu	*	Ni	*	O	*	P	*	Pb	*	S	*	Sn	*	Te	*	Zn
1	4	99.35	8	0.00107	2	0.001073	12	0.004998	12	0.002465	3	0.0258	12	0.0016856	12	0.4293	3	0.0035
2	16	[99.37333]	5	0.00136	2	0.0011	12	0.00511	12	0.002550	1	0.026433	4	0.0020	12	0.470275	14	0.0035667
3	16	[99.38667]	12	0.002022	2	0.00118	4	0.005667	9	0.002567	12	0.02655	12	0.00211	12	0.47735	4	0.0036667
4	4	99.39333	12	0.00204	2	0.001233	3	0.006	3	0.003	12	0.026775	14	0.0023	12	0.481725	4	0.0039667
5	17	99.39667	12	0.002115	2	0.001307	12	0.006596	5	0.003	1	0.029967	12	0.002306	4	0.5000	12	0.005283
6	16	[99.39667]	12	0.002152	2	0.001447	3	0.0079	4	0.0034	12	0.030575	3	0.0024	4	0.501133	12	0.005307
7	14	99.4	12	0.0022	2	0.001467	4	0.008	12	0.003413	1	0.0361	4	0.002433	12	0.509375	12	0.005548
8	16	[99.43513]	12	0.002218	2	0.00179	3	0.0100	12	0.003564	1	0.036667	12	0.002767	12	0.51785	12	0.00557
9	4	99.45	5	0.002233	4	0.002	3	0.0101	4	0.003667	1	0.036833	5	0.00328	14	0.519333	12	0.0055867
10	16	[99.94]	4	0.002267	12	0.002624	3	0.0106	5	0.00382	1	0.0370	5	0.003333	12	0.522625	12	0.00561
11	3	99.95	12	0.002302	2	0.0031	14	0.010933	12	0.003855	1	0.038567	4	0.003567	4	0.523	5	0.005933
12	12	100	3	0.003			3	0.0110	12	0.003997	1	0.039533	5	0.004	4	0.526333	4	0.006
13	12	100	5	0.003			5	0.011133	12	0.0040	12	0.040667	3	0.004	4	0.529	5	0.006617
14	12	100	14	0.003033			4	0.0113	5	0.004	1	0.042867			17	0.533333	12	0.006733
15			4	0.003167			5	0.011333			1	0.044			4	0.536667	4	0.007227
16			4	0.004			3	0.011967							4	0.538867		
17			4	0.004			4	0.015667							4	0.549333		
18			3	0.0044			12	0.015667							4	0.55		
Average		99.47		0.002588		0.001734		0.00969		0.00309		0.034556		0.002783		0.511972		0.00533
Std Dev		0.015000		0.000075		0.000058		0.00036		0.00013		0.000082		0.000088		0.000075		0.00021
H		0.458137		0.00047		0.00041		0.00078		0.00050		0.0014		0.00048		0.0065771		0.0006149
U₁		0.46		0.00048		0.00042		0.00086		0.00052		0.0014		0.00049		0.0066		0.00065
t-statistic		2.16		2.11		2.23		2.11		2.16		2.14		2.18		2.11		2.1447867
U₂		0.99		0.0010		0.00093		0.0018		0.0011		0.0030		0.0011		0.014		0.0014
U₃		0.26		0.00024		0.00028		0.0004		0.00030		0.00078		0.00030		0.0033		0.00036
Certified		99.6		0.0026		0.0017		0.010		0.0031		0.035		0.0028		0.51		0.0053
Uncertainty		0.3		0.0006		0.0005		0.001		0.0007		0.008		0.0007		0.02		0.0007
Tolerance		1.0		0.0018		0.0015		0.003		0.0021		0.024		0.0021		0.06		0.0021

BS 14500A   * Code for method   Informational values listed as weight percent

Analysis	*	Al	*	C	*	Ca	*	Co	*	Fe	*	Mg	*	Mn	*	N	*	Sb	*	Si	*	Zr
1	12	0.000000220	3	0.0002	12	0.000000894	12	0.000026	12	0.000723	12	0.000000687	12	0.00000578	2	0.000267	12	0.0006933	12	0.000000891	5	0.00005
2	12	0.000000279	1	0.000433	12	0.00000102	12	0.00002795	12	0.000844	12	0.000000696	12	0.00000613	2	0.000322	4	0.0007	12	0.000002	3	0.0010
3	12	0.0000006848	1	0.0005	12	0.000001198	12	0.00002848	12	0.000857	12	0.000000744	12	0.00000665	12	0.000377	12	0.000718	12	0.00000448	3	0.0017
4	12	0.00000687	1	0.00069	3	0.00004	12	0.00002875	12	0.000891	12	0.000002	12	0.000008	2	0.0005	12	0.000898	12	0.000026675	4	0.0019
5	5	0.0002133	1	0.000767	4	0.00015667	5	0.00004	12	0.000897	3	0.0001	4	0.0004	12	0.000507	12	0.000952	7	0.00015667		
6	3	0.0004	1	0.00089			5	0.00004667	12	0.000904	5	0.0001	3	0.002	4	0.001	4	0.004	5	0.0006		
7	4	0.0012	1	0.001			3	0.0005	12	0.000907	4	0.0001			12	0.001192	12	0.00988	4	0.0008		
8	3	0.0015	1	0.001533			4	0.0005	4	0.001367	4	0.0002					12	0.011625	4	0.0032		
9	14	0.0020	1	0.002033			3	0.003	3	0.002							12	0.012625	3	0.0037		
10	4	0.002	1	0.002043					4	0.004									14	0.003833		
11																			4	0.003933		
12																			3	0.004		
13																			4	0.004133		
Average		0.0007		0.0025		0.0000399		0.00047		0.0013		0.0000630		0.00040		0.0006		0.005		0.0019		0.0012
Std Dev		0.0013		0.0092		0.0000024		0.00057		0.0039		0.0000062		0.00052		0.0010		0.029		0.0060		0.0049
H		0.0003		0.00046673		0.00019		0.00029		0.0004		0.00020		0.00027		0.0003039		0.001		0.0004		0.0004
U₁		0.0013		0.0092		0.00019		0.00064		0.0039		0.00020		0.00059		0.0011		0.029		0.0060		0.0049
t-statistic		2.26		2.16		2.78		2.31		2.26		2.36		2.57		2.45		2.31		2.18		3.1824463
U₂		0.0030		0.020		0.00052		0.0015		0.0088		0.00046		0.0015		0.0027		0.066		0.013		0.016
U₃		0.00096		0.0053		0.00023		0.00049		0.0028		0.00016		0.00062		0.0010		0.022		0.0036		0.0078
Informational		(0.0007)		(0.003)		(0.00004)		(0.0005)		(0.001)		(0.00006)		(0.0004)		(0.0006)		(0.005)		(0.002)		(0.001)

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 14500A   * Code for analytical method   Trace analysis listed as mg/kg   (ppm)

Analysis	*	Ag	*	As	*	Au	*	B	*	Bi	*	Cd	*	Cl	*	Cr	*	Ga	*	Ge
1	3	10	12	2.3	12	0.02	3	0.004	12	0.66	12	0.04	12	0.01	12	0.043	12	0.01	12	0.85
2	4	20	12	2.3	12	0.03	3	1	12	0.68	12	0.09	12	0.02	3	10	12	0.02	12	0.85
3	5	20.2	12	2.3	12	0.04			12	0.69	12	0.09	12	0.03			12	0.02	12	0.88
4	5	20.2	12	2.357					4	20	3	90								
5	5	20.9	12	2.377																
6	12	21	12	2.427																
7	12	22	4	3																
8	12	22	4	30																

Analysis	*	In	*	Mo	*	Nb	*	Ru	*	Se	*	Ti	*	W
1	12	0.03	12	0.0085	3	4	12	0.009	12	1.3	3	4	12	0.00733
2	12	0.04					12	0.01	12	1.3			3	60
3	12	0.09					12	0.01	12	1.4				
4									4	30				

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	17	PIXE
6	Gravimetric	12	GD Mass Spectrometry		

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
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Exova	Glendale Heights, Il	A2LA	17025
Dirats Laboratories	Westfield, MA	ANAB	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
National Analysis for Iron and Steel	Beijing, China	CNAS	17025

A2LA = American Association for Laboratory Accreditation
ANAB = ANSI-ASQ National Accreditation Board
CNAS = China National Accreditation Service
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: 39X17866, 39X17868, 39X17869; AR 147, 149, 673, 892, 1652, 1653; BAM 222, 228, 361; BAS 180/2, 183/4, 390; BS 110A, 110B, 405C, 510B, 544A, 544B, 630C, 675B, 706C, 922A, 932E, 18150, 181050A; IARM 71B, 80B, 226A, 279A; DSZU CA01a; KMS LSCON-001; LECO 51-147, 501-402, 501-992, 502-416, 502-873, 502-874; SRM C1107, 19F, 55D, 62, 62D, 158A, 164A, 361, 400, 459, 1112, 1113, 1114, 1413, 3109A, 3156, 3161A, 3169.

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 228, 361; BAS 180/2; BS 110A, 110B, 544A, 544B, 922A, 932E, 18150; DSZU CA01a; IARM 279A; KMS LSCON-001; LECO 502-873.

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 14500A 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 IUSA, S.A.; Jocotitlan, Mexico.

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 14500A-091417. 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 September 14, 2017.

Beau R. Brammer

President