

Brammer Standard Company, Inc.

Certificate of Analysis

BS Cu997

Certified Reference Material for Commercially Pure Copper

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
C	0.0007	0.0003		P	0.0055	0.0008
Cu	99.7	0.2		Pb	0.0008	0.0003
Fe	0.0032	0.0004		Sn	0.0003	0.0001
Ni	0.0004	0.0002		Zn	0.0006	0.0002
O	0.0039	0.0004				

	Reference Value ¹	Estimate of Uncertainty ²	Reference Values^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
S	0.006	0.001			

Informational Values^{3,5}

Al (0.002)	As (0.0008)	Ca (0.0001)	Co (0.001)	Cr (0.0003)
Mg (0.0005)	Mn (0.001)	N (0.0007)	Sb (0.0002)	Si (0.0009)
Zr (0.007)				

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. 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 Ag, Au, B, Bi, Cd, Cl, Ga, Ge, In, Mo, Pd, Pt, Ru, Se, Te, and V are shown on page 4.

The requirements of ISO Guides 30, 31, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis.

BS Cu997 * Code for method Certified values listed as weight percent

Analysis	*	C #	* Cu	* Fe	* Ni	* O	* P	* Pb	* Sn	* Zn #
1	1	0.0002726667	16 [99.39667]	12 0.00256666667	12 0.000331525	12 0.0023252	12 0.00202895	12 0.000023175	4 0.0002	12 0.0005266
2	1	0.0005	4 99.923	12 0.002784725	12 0.000336875	2 0.0025	12 0.0021403	12 0.0000233	5 0.0002	12 0.0005274
3	1	0.0005666667	16 [99.9375]	12 0.002839425	12 0.000337575	12 0.0031265	12 0.002299325	12 0.000026375	4 0.00023333	12 0.000547
4	1	0.0006	16 [99.94]	12 0.002879175	12 0.000339575	2 0.0037533	4 0.0042	4 0.0001	3 0.00026667	5 0.00055
5	1	0.0007	3 99.944	4 0.002933333333	12 0.00034625	2 0.0038	4 0.0047	4 0.000366667	4 0.00026667	12 0.0005503
6	1	0.0007333333	6 99.956	12 0.002956075	12 0.000349525	12 0.0038167	7 0.005223333	3 0.00055	12 0.00028448	12 0.0005633
7	1	0.0007666667	16 [99.9565]	12 0.0029825	5 0.0003966667	2 0.0039333	4 0.005233333	4 0.000633333	12 0.00029095	12 0.0005707
8	1	0.001	16 [99.96]	12 0.003005425	12 0.00041	2 0.0040	4 0.005366667	4 0.0007	12 0.00030203	12 0.00071
9	1	0.0011466667	16 99.9633]	4 0.0031	4 0.0004333333	2 0.00434	4 0.005576667	12 0.0009186	12 0.00030795	5 0.0007167
10	3	0.00115	4 99.9633	4 0.003293333333	4 0.0007	2 0.0043533	4 0.005666667	12 0.00092315	12 0.00031498	5 0.00072
11			16 [99.97]	5 0.0034	4 0.0007666667	2 0.0044733	4 0.006066667	12 0.00093955	12 0.00033148	4 0.0007667
12			12 99.97	5 0.00350		2 0.00451	3 0.006125	12 0.0009735	12 0.00037667	4 0.0008033
13			10 99.99	3 0.004		2 0.0053	3 0.007	5 0.001	5 0.00044667	4 0.0008333
14			12 100.00	5 0.00433333333			5 0.007333333	12 0.00103	5 0.00048	
15			12 100.00	4 0.0044			12 0.0074	12 0.001089375	5 0.0005	
16			12 100.00	10 0.0059			5 0.0095	5 0.0011		
17				4 0.0071				12 0.001114675		
18								5 0.001133333		
Average		0.00074	99.693	0.003223	0.000429	0.00386	0.00552	0.000787	0.000275	0.000645
Std Dev		0.00010	0.012	0.000080	0.000033	0.00015	0.00017	0.000099	0.000025	0.000088
H		0.0003434187	0.32	0.00056	0.000293	0.00060	0.00069	0.00035	0.00026	0.0003295
U ₁		0.00036	0.32	0.00057	0.00029	0.00062	0.00072	0.00036	0.00026	0.00034
t-statistic		2.26	2.13	2.12	2.23	2.18	2.13	2.11	2.14	2.18
U ₂		0.00081	0.69	0.0012	0.00066	0.0014	0.0015	0.00077	0.00056	0.00074
U ₃		0.00026	0.17	0.00029	0.00020	0.00038	0.00038	0.00018	0.00014	0.00021
Certified		0.0007	99.7	0.0032	0.0004	0.0039	0.0055	0.0008	0.0003	0.0006
Uncertainty		0.0003	0.2	0.0004	0.0002	0.0004	0.0008	0.0003	0.0001	0.0002
Tolerance		0.0006	0.7	0.0012	0.0004	0.0014	0.0024	0.0007	0.0002	0.0005

Unweighted mean and standard deviation were used to calculate Carbon and Zinc.
 The weighted mean for C is 0.000429 and standard deviation is 0.000034. The weighted certified value is 0.0004 with an uncertainty of 0.0002 and a tolerance of 0.0004.
 The weighted mean for Zn is 0.000770 and standard deviation is 0.000050. The weighted certified value is 0.0008 with an uncertainty of 0.0002 and a tolerance of 0.0008.

BS Cu997 * Code for method Reference values listed as weight percent

Analysis	*	S
1	3	0.002
2	1	0.0035
3	1	0.00437
4	12	0.0048090
5	12	0.004904975
6	1	0.0050
7	12	0.005115925
8	3	0.005675
9	1	0.0059
10	1	0.0060666667
11	1	0.0064
12	1	0.0065
13	1	0.0070333333
14	1	0.0074
15	12	0.0078666667
16	1	0.0080733333
17	1	0.0081333333
Average		0.00562
Std Dev		0.00019
H		0.00070
U ₁		0.00073
t-statistic		2.12
U ₂		0.0015
U ₃		0.00037
Reference		0.006
Uncertainty		0.001
Tolerance		0.003

Analysis	*	Al	*	As	*	Ca	*	Co	*	Cr	*	Mg	*	Mn	*	N	*	Sb	*	Si
1	12	0.00000491	5	0.0000767	12	0.0000096825	5	0.000005	12	0.0000012	12	0.0000013	12	0.0000613	2	0.0000533	12	0.0001333	12	0.00002778
2	12	0.0000007145	5	0.00013	12	0.000001	12	0.00000915	4	0.0001	12	0.000001425	12	0.00006145	2	0.0000906	12	0.0001748	12	0.000028475
3	12	0.000001406	5	0.00013	12	0.0000011	12	0.00000925	4	0.0001333	12	0.00000145	12	0.0000624	2	0.0000926	12	0.0001749	12	0.000029750
4	12	2.1E-06	12	0.00013445	12	0.000018	12	0.000009475	3	0.0008	12	0.000005	12	0.000087	2	0.00026667	12	0.000175	12	0.000054667
5	5	0.00027	12	0.00013745	4	0.0002	12	0.000009667			4	0.0011	4	0.0001	12	0.00034383	12	0.0001767	7	0.000233333
6	5	0.0003533333	12	0.00013985	3	0.00035	4	0.0004333333			4	0.001333333	5	0.00011	12	0.00041105	12	0.0001862	4	0.0010
7	4	0.0009666667	12	0.00014			4	0.0006666667			3	0.0013975	5	0.000113333	12	0.00207223	12	0.0001973	4	0.001233333
8	3	0.002	3	0.0004			4	0.0013666667					4	0.000133333	2	0.0024	4	0.0002333	4	0.001433333
9	3	0.003125	4	0.000433333			3	0.00265					4	0.0003			4	0.0004333	3	0.001475
10	4	0.0031333333	4	0.000466667			4	0.007					3	0.000375					4	0.003866667
11	4	0.0036	4	0.0061									4	0.0004						
12	4	0.0046											3	0.011						
Average		0.0015		0.0008		0.000096		0.0012		0.00026		0.00055		0.0011		0.0007		0.00021		0.0009
Std Dev		0.0043		0.0013		0.000020		0.0033		0.00025		0.00089		0.0024		0.0014		0.00010		0.0021
H		0.0004		0.0004		0.00020		0.0004		0.00026		0.00031		0.0004		0.0003		0.00024		0.0004
U ₁		0.0043		0.0014		0.00020		0.0033		0.00036		0.00095		0.0024		0.0014		0.00026		0.0021
t-statistic		2.20		2.23		2.57		2.26		3.18		2.45		2.20		2.36		2.31		2.26
U ₂		0.010		0.0030		0.00053		0.0075		0.0011		0.0023		0.0053		0.0034		0.00061		0.0047
U ₃		0.0028		0.00091		0.00021		0.0024		0.00057		0.00088		0.0015		0.0012		0.00020		0.0015
Informational		(0.002)		(0.0008)		(0.0001)		(0.001)		(0.0003)		(0.0005)		(0.001)		(0.0007)		(0.0002)		(0.0009)

Analysis	*	Zr																		
1	5	0.00001667																		
2	3	0.001																		
3	4	0.0025																		
4	4	0.0156666667																		
5	3	0.01575																		
6																				
7																				
8																				
9																				
10																				
Average		0.007																		
Std Dev		0.065																		
H		0.001																		
U ₁		0.065																		
t-statistic		2.78																		
U ₂		0.18																		
U ₃		0.081																		
Informational		(0.007)																		

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 multiplied by 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 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 Cu997

* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ag	*	Au	*	B	*	Bi	*	Cd	*	Cl	*	Ga	*	Ge	*	In	*	Mo
1	4	80	12	0.05	12	0.002	12	0.3	12	0.04	12	0.009	12	0.21	12	0.11	12	0.01	12	0.009
2	4	95	12	0.05	12	0.002	12	0.31	12	0.06	12	0.009	12	0.22	12	0.13	12	0.01	12	0.01
3	4	96	12	0.08	12	0.003	12	0.34	12	0.08	12	0.02	12	0.26	12	0.13	12	0.02	12	0.01
4	4	97.3					3	40	3	80										
5	4	98																		
6	12	120																		
7	12	120																		
8	12	120																		
9	4	193																		
Analysis	*	Pd	*	Pt	*	Ru	*	Se	*	Te	*	V								
1	12	0.01	12	0.01	12	0.005	12	0.83	12	0.5288	12	0.001								
2	12	0.03					12	0.91	12	0.547										
3	12	0.04					12	0.93	12	0.5543										
4									12	0.556										
5									12	0.5966										
6									12	0.6415										
7									12	0.67										
8									12	0.68										
9									12	0.68										

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
LECO Corporation	St. Joseph, MI	A2LA	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
TUV Rheinland	Bangalore, India	NABL	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Exova	Santa Fe Springs, CA	A2LA	17025
Exova	Glendale Heights, IL	A2LA	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: 31XB28, 39XCT6; AR 645, 657, 662, 673, 892, 1653; BAM 222, 228, 361, 366; BAS 180/2, 183/4, 390; BS 110A, 110B, 863B, 932F, 18150A; IARM 70B, 80B, 279A; DSZU CA01a; KMS LCSON-001; LECO 501-147, 501-402, 501-550, 501-953, 502-868, 502-873; SRM C1251, C1252, C1253, 158A, 166B, 396, 400, 1112, 1113, 1114, 1252, 1413, 3101, 3109A, 3128, 3150, 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, 18150A; DSZU CA01a; KMS LCSON-001; IARM 279A; LECO 502-873; SRM C1251, C1252, 1113.

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 Cu997 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 is unknown.

Form: This CRM is forged 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 Cu997-120717. 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.
14603 Benfer Road
Houston, Texas 77069-2895 USA

Phone: (281) 440-9396 Web: www.brammerstandard.com

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 December 6, 2017.

Beau R. Brammer

President