Brammer Standard Company, Inc.

Certificate of Analysis

BS 171C

Certified Reference Material for Cobalt Base Alloy Stellite 25 - UNS Number R30605

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
C	**0.119**	0.004	**Mn**	**1.47**	0.03
Co	**51.2**	0.7	**N**	**0.0045**	0.0005
Cr	**20.3**	0.2	**Ni**	**10.1**	0.2
Fe	**1.07**	0.05	**W**	**15.3**	0.2

Informational Values[3,4]

Al (0.04)	B (0.004)	Cu (0.02)	La (0.03)	Mg (0.001)
Mo (0.08)	Nb (0.006)	O (0.002)	P (0.008)	S (0.0008)
Si (0.1)	Ta (0.02)	Ti (0.07)	V (0.009)	Zr (0.01)

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

Trace element information values for Ga, Ir, Os, Pb, Re, Sb, Sn, U, and Zn 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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* Code for method Certified values listed as weight percent

Analysis	*	C	*	Co	*	Cr	*	Fe	*	Mn	*	N	*	Ni	*	W
1	1	0.107	16	50.3675	4	20	3	1.01	10	1.425	2	0.0026	4	9.686567	17	15.047
2	1	0.11	16	50.395	4	20.03	4	1.011666667	4	1.428333	2	0.0036667	4	9.762333	4	15.07333
3	3	0.1156	16	50.4125	10	20.06	4	1.015333333	4	1.43	2	0.0042333	10	9.864	4	15.08367
4	1	0.115667	16	50.5	4	20.09667	3	1.0178	8	1.432667	2	0.0045433	10	9.906667	10	15.095
5	1	0.116	4	50.66333	3	20.1	10	1.02	4	1.437	2	0.0047333	4	9.911667	4	15.09667
6	11	0.1175	10	50.76333	4	20.12333	10	1.027	3	1.4378	2	0.0048	6	9.912667	4	15.19667
7	1	0.118	16	50.7925	10	20.18	4	1.040333333	4	1.44	2	0.0048	4	9.931333	14	15.2
8	1	0.1182	10	50.877	13	20.24567	4	1.046	4	1.445333	2	0.00488	3	9.9389	10	15.22
9	1	0.118333	14	51.1	14	20.36667	4	1.06	3	1.45	2	0.00491	17	9.951	4	15.29667
10	1	0.118833	3	51.22	10	20.39667	10	1.062	4	1.450333	2	0.0049333	4	9.996667	11	15.31
11	1	0.1190	10	51.29	13	20.39747	4	1.076	10	1.473333	2	0.0050003	4	10.10	3	15.3125
12	1	0.119033	4	51.31537	3	20.399	4	1.078066667	10	1.478			10	10.138	11	15.3225
13	3	0.12	13	51.398	4	20.40533	10	1.08	11	1.4825			4	10.19333	4	15.34
14	11	0.12225	4	51.85333	4	20.43333	14	1.08	4	1.485333			3	10.20	4	15.38667
15	3	0.1235	16	52.04667	3	20.4825	17	1.095333333	17	1.486			10	10.2	3	15.4075
16	3	0.125	16	52.31032	11	20.515	4	1.101566667	4	1.488667			3	10.315	4	15.44
17	1	0.125333	4	52.48	11	20.5175	3	1.1075	10	1.49			2	10.33333	4	15.5106
18	1	0.128467			4	20.52	3	1.1425	3	1.49			4	10.4009	3	15.524
19					10	20.526	11	1.1525	3	1.495			3	10.41	10	15.563
20							11	1.16	4	1.4972			11	10.56		
21									11	1.5						
22									14	1.506667						
Average		0.1194		51.163815		20.305007		1.069180		1.4751		0.00455		10.085618		15.285567
Std Dev		0.0025		0.000077		0.000073		0.000071		0.0067		0.00020		0.000071		0.000073
H		0.003323		0.131853		0.069899		0.011037729		0.01333		0.0007316		0.043995		0.057821
U1		0.0041		0.13		0.070		0.011		0.015		0.00076		0.044		0.058
t-statistic		2.109816		2.119905		2.100922		2.093024054		2.08		2.2281389		2.093024		2.100922
U2		0.0087		0.28		0.15		0.023		0.031		0.0017		0.092		0.12
U3		0.0021		0.068		0.034		0.0052		0.0066		0.00051		0.021		0.028
Certified		**0.119**		**51.2**		**20.3**		**1.07**		**1.47**		**0.0045**		**10.1**		**15.3**
Uncertainty		0.004		0.7		0.2		0.05		0.03		0.0005		0.2		0.2
Tolerance		0.012		2.1		0.6		0.15		0.09		0.0017		0.6		0.6

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* Code for method Informational values listed as weight percent

Analysis	*	Al	*	B	*	Cu	*	La	*	Mg	*	Mo	*	Nb	*	O	*	P	*	S
1	12	0.025667	12	0.000167	5	0.00020	12	0.00001033	5	0.0002	4	0.031	5	0.00035	2	0.000133	12	0.000433	12	0.000051
2	3	0.0289	5	0.000567	12	0.000867	5	0.0002	12	0.000267	10	0.05	5	0.0004	2	0.000374	3	0.0006	1	0.000227
3	4	0.030733	7	0.00069	5	0.001113	4	0.0421	5	0.000397	12	0.0586667	5	0.000533	2	0.000433	5	0.001523	1	0.00041
4	5	0.0357	11	0.00155	5	0.0012	11	0.048525	4	0.000503	4	0.0652333	10	0.002	2	0.000633	7	0.001727	3	0.0005
5	4	0.0398	14	0.001733	8	0.00137	14	0.0502	14	0.001433	5	0.0693667	14	0.007833	2	0.000633	11	0.002	1	0.00058
6	4	0.040167	4	0.0018	14	0.001933	11	0.05305	3	0.00144	10	0.0699	4	0.008	2	0.00087	11	0.002	1	0.000633
7	14	0.0403	3	0.0021	10	0.002			4	0.002	17	0.070	11	0.008425	2	0.00091	14	0.0028	3	0.000775
8	4	0.042133	4	0.0021	3	0.003			4	0.00237	10	0.070	2	0.010	2	0.0010	3	0.003125	11	0.0008
9	11	0.0424	11	0.002875	3	0.0116					10	0.071	3	0.0115	2	0.001433	5	0.003133	3	0.000825
10	11	0.0426	3	0.004488	4	0.012					4	0.0717333	4	0.012833	2	0.004	4	0.003267	11	0.000975
11	4	0.0427	3	0.004798	4	0.025167					4	0.0727333			2	0.0086	4	0.003333	1	0.001
12	4	0.045233	4	0.027667	11	0.029375					4	0.0727667					10	0.0034	1	0.001433
13	3	0.0492			11	0.02945					5	0.0739333					3	0.004525	1	0.002
14	4	0.049367			10	0.0297					3	0.074					4	0.006		
15					4	0.031567					14	0.0787333					17	0.087333		
16					10	0.037					3	0.096575								
17					3	0.0922					3	0.09825								
18					3	0.093925					4	0.1313333								
19											4	0.1324								
20											3	0.1328								
21											11	0.13275								
22											4	0.158								
Average		0.04		0.004		0.02		0.03		0.0011		0.08		0.006		0.0017		0.008		0.0008
Std Dev		0.23		0.021		0.13		0.30		0.0030		0.32		0.039		0.0057		0.047		0.0013
H		0.00193		0.000694		0.001394		0.001683428		0.00042		0.002712		0.000821		0.000495		0.000928		0.000374
U1		0.23		0.021		0.13		0.30		0.0030		0.32		0.039		0.0057		0.047		0.0014
t-statistic		2.160369		2.200985		2.109816		2.570581835		2.364624		2.0930241		2.262157		2.228139		2.144787		2.178813
U2		0.50		0.047		0.26		0.77		0.0071		0.66		0.089		0.013		0.10		0.0030
U3		0.13		0.014		0.062		0.32		0.0025		0.15		0.028		0.0038		0.026		0.00082
Informational		**(0.04)**		**(0.004)**		**(0.02)**		**(0.03)**		**(0.001)**		**(0.08)**		**(0.006)**		**(0.002)**		**(0.008)**		**(0.0008)**

BS 171C * Code for method Informational values listed as weight percent

Analysis	*	Si	*	Ta	*	Ti	*	V	*	Zr
1	12	0.022333	5	0.00009	12	0.035333	10	0.001	3	0.0084
2	4	0.032	14	0.0033	3	0.0501	5	0.002866667	4	0.0092
3	5	0.0337	11	0.003775	10	0.0527	4	0.004	4	0.0128
4	4	0.039467	4	0.012667	17	0.053333	12	0.004033333		
5	4	0.046733	4	0.019	10	0.060	5	0.0051		
6	4	0.047067	11	0.031825	11	0.06195	14	0.005333333		
7	6	0.047767	3	0.0456	4	0.062233	5	0.006586667		
8	11	0.048275	4	0.063833	5	0.0637	3	0.0068		
9	3	0.048575			4	0.064567	3	0.007825		
10	4	0.049133			5	0.065833	4	0.00985		
11	3	0.04925			4	0.065933	4	0.0105		
12	14	0.049667			4	0.068067	11	0.0131		
13	4	0.0518			3	0.069075	4	0.013133333		
14	11	0.052925			4	0.0706	3	0.013875		
15	10	0.057267			4	0.072	4	0.0154		
16	10	0.074			4	0.0728	11	0.0186		
17	17	1.199333			14	0.072933				
18					11	0.074075				
19					4	0.0769				
20					3	0.0883				
Average		0.11		0.02		0.07		0.009		0.01
Std Dev		0.42		0.35		0.28		0.047		0.13
H		0.003186		0.001394		0.002537		0.00097642		0.001022
U1		0.42		0.35		0.28		0.047		0.13
t-statistic		2.119905		2.364624		2.093024		2.131449544		4.302653
U2		0.89		0.84		0.58		0.10		0.57
U3		0.22		0.30		0.13		0.025		0.33
Informational		(0.1)		(0.02)		(0.07)		(0.009)		(0.01)

For each element, in accordance with the requirements of ISO 17034 and Guide 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 171C * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ga	*	Ir	*	Os	*	Pb	*	Re	*	Sb	*	Sn	*	U	*	Zn
1	12	15	12	0.05	12	0.05	12	0.52	12	0.09	12	1.0	12	0.29	12	0.007	12	1.0
2	12	15	12	0.05	12	0.07	12	0.52	12	0.09	12	1.2	12	0.30	12	0.008	12	1.2
3	12	15	12	0.05	12	0.08	12	0.54	12	0.014	12	1.2	12	0.31	12	0.010	12	1.3

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
Evans Analytical Group	Liverpool, NY	A2LA	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
Exova	Glendale Heights, IL	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Luvak Inc.	Boylston, MA	PRI	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	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
PCA = Polish Center For Accreditation
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: 24XWASP40, 24X26310, 112X14360, 112X14930; AR 164, 654, 657, 662, 668, 673, 675, 876, 882, 888, 892, 1648, 1652, 1653; BAM 321-1; BS HON U, 170, 171, 171A, 171B, 172, 172A; DSZU CA01A; ECRM 299-1, 327-2; IARM Co6B-18, 62E, 64C, 96A, 96B, 96C, 96D, 97B, 98B, 207A, 208B; IMZ 124, 131, 157, 186, 188; LECO 501-501, 501-503, 501-504, 501-676, 501-991, 502-414, 502-449, 502-712, 502-855, 502-868, 502-904, 502-916; NCS NS 20035; SRM 15G, 33D, 36, 168, 862, 1199, 1242, 1413, 3131A.

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 — BS HON U, 170, 171, 171A, 172, 172A; ECRM 299-1, 327-2; IMZ 186; DSZU CA01A; LECO 501-676, 502-916; NCS NS 20035; SRM 1199, 1242.

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 171C 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 ATI Specialty Materials; Richburg, South Carolina.

Form: This CRM is machined in the form of a disc, approximately 38mm in diameter and 19mm 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 171C-080819. 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) 440-9396Web: 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 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 9001:2015 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 08, 2019.

Beau R. Brammer

President