

Brammer Standard Company, Inc.

Certificate of Analysis

BS 172B

Certified Reference Material for Stellite 188 Cobalt Base Alloy - UNS Number R30188

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.21	0.02		N	0.001
C	0.055	0.003		Nb	0.004
Co	34.8	0.3		Ni	0.2
Cr	22.8	0.3		O	0.0004
Fe	2.46	0.07		Si	0.02
La	0.059	0.005		Ti	0.005
Mn	0.97	0.02		V	0.0008
Mo	0.28	0.02		W	0.1

Informational Values^{3,4}

As (0.05)	B (0.004)	Cu (0.02)	Mg (0.001)	P (0.008)
S (0.0009)	Ta (0.01)	Zr (0.008)		

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, Ba, Ce, Ga, Ge, Ir, Li, Nd, Os, Pb, Pr, Re, Sb, Sn, Ti, 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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Analysis	*	Al	*	C	*	Co	*	Cr	*	Fe	*	La	*	Mn	*	Mo	*	N	*	Nb
1	14	0.1736667	1	0.04413333	10	34.42	3	22.16	4	2.3316667	4	0.05328	3	0.948	4	0.12733	2	0.03087	14	0.0369
2	4	0.1843333	3	0.049	13	34.4296667	4	22.335	4	2.3456667	11	0.0541	8	0.95033	4	0.2297	2	0.0321	4	0.0369667
3	15	0.1933333	1	0.052	4	34.4666667	4	22.49	10	2.35	12	0.0550	4	0.955	3	0.237	2	0.03237	10	0.037
4	4	0.1935	1	0.05226667	4	34.5736	3	22.5	4	2.355	14	0.058733	11	0.957	14	0.26133	2	0.0327	4	0.0379333
5	4	0.197	1	0.0534	16	34.5866667	13	22.5241333	11	2.39	4	0.0619	10	0.96	4	0.26433	2	0.0331	4	0.0384
6	4	0.2017667	11	0.0538	4	34.6233333	14	22.5333333	3	2.40	5	0.062267	4	0.965	4	0.27423	2	0.03311	5	0.0395333
7	4	0.2047	1	0.05484	10	34.78	11	22.72	4	2.4086667	4	0.062333	14	0.96933	10	0.276	2	0.0335	11	0.0402
8	4	0.208	1	0.05486667	16	34.92	10	22.73	4	2.4267	3	0.063	4	0.97037	4	0.27757	2	0.03353	4	0.0407333
9	10	0.2126667	1	0.05496667	16	35.0484493	10	22.84	4	2.4333333	4	0.0656	10	0.97367	15	0.279	2	0.03413	3	0.042
10	4	0.2213333	1	0.055	16	35.09	4	22.856	10	2.439			4	0.9766	10	0.28132	2	0.0350	12	0.0423333
11	11	0.225	1	0.05566667	16	35.1	4	22.9	14	2.4533333	3	0.98	10	0.28167	2	0.03607	4	0.0449333		
12	4	0.2293667	1	0.0562	14	35.3666667	13	22.973	4	2.4609333	3	0.980	3	0.284					4	0.0449667
13	3	0.237	1	0.05716667			10	22.9866667	4	2.4772667	4	0.982	4	0.28967					4	0.045
14	3	0.257	1	0.0599			18	23.0359667	4	2.501	4	0.985	10	0.29					10	0.046
15			3	0.06			4	23.0926667	3	2.506	4	0.98637	4	0.29167					3	0.0465
16			3	0.0602			4	23.52	3	2.52	4	0.988	12	0.29667					10	0.046517
17							10	23.5378	10	2.55391	4	1.0133	17	0.30833						
18									10	2.5733333			10	1.016	3	0.31				
19									17	2.5766667				4	0.31423					
20														11	0.342					
Average		0.2125		0.0551		34.78		22.81		2.463		0.0592		0.9738		0.2763		0.0333		0.0416
Std Dev		0.0031		0.0017		0.31		0.38		0.011		0.0021		0.0077		0.0036		0.0011		0.0036
H		0.0044		0.0022		0.10		0.076		0.018		0.0023		0.010		0.0051		0.0017		0.0020
U ₁		0.0054		0.0028		0.10		0.099		0.021		0.0031		0.013		0.0062		0.0021		0.0024
t-statistic		2.16		2.13		2.20		2.12		2.10		2.31		2.11		2.09		2.23		2.13
U ₂		0.012		0.0059		0.22		0.21		0.045		0.0072		0.027		0.013		0.0046		0.0051
U ₃		0.0031		0.0015		0.064		0.051		0.010		0.0024		0.0064		0.0029		0.0014		0.0013
Certified		0.21		0.055		34.8		22.8		2.46		0.059		0.97		0.28		0.033		0.042
Uncertainty		0.02		0.003		0.3		0.3		0.07		0.005		0.02		0.02		0.001		0.004
Tolerance		0.06		0.009		0.9		0.9		0.21		0.015		0.06		0.06		0.005		0.012

Analysis	*	Ni	*	O	*	Si	*	Ti	*	V	*	W									
1	4	22.286	2	0.0005	4	0.28466667	10	0.06916667	14	0.0065333	10	14.90333									
2	3	22.3	2	0.0006	4	0.287	17	0.07133333	4	0.0067	11	14.98									
3	4	22.323333	2	0.000672	10	0.29	4	0.07373333	12	0.0068333	17	15.03367									
4	14	22.333333	2	0.00085333	3	0.31	4	0.07396667	3	0.0073	4	15.0784									
5	10	22.4	2	0.00103333	3	0.321	10	0.074	4	0.0080333	4	15.14									
6	10	22.415	2	0.0013	4	0.3317	5	0.0740	4	0.0083333	10	15.22									
7	6	22.425333	2	0.0015	14	0.33233333	4	0.07573333	4	0.0084333	4	15.22027									
8	3	22.43	2	0.00152	6	0.33296667	5	0.0765	4	0.0087	3	15.228									
9	4	22.5	2	0.00163333	11	0.333	4	0.07803333	11	0.0087	14	15.26667									
10	4	22.525233			4	0.33776	3	0.0807	5	0.00876	4	15.28333									
11	11	22.65			6	0.33975	4	0.0833	4	0.00885	10	15.317									
12	10	22.693333			3	0.347	4	0.0835	10	0.009	4	15.31903									
13	17	22.711			10	0.36433333	4	0.08453	5	0.0092333	4	15.32333									
14	4	22.773333			10	0.36904	4	0.0846			10	15.34402									
15	4	22.900333			4	0.37	14	0.0848			4	15.36933									
16	4	23.07					11	0.0897			4	15.37667									
Average		22.55		0.00107		0.3295		0.0786		0.00814		15.199									
Std Dev		0.23		0.00011		0.0050		0.0059		0.00032		0.044									
H		0.075		0.00041		0.0056		0.0027		0.00092		0.057									
U ₁		0.091		0.00042		0.0075		0.0032		0.00097		0.073									
t-statistic		2.13		2.31		2.14		2.13		2.18		2.13									
U ₂		0.19		0.0010		0.016		0.0069		0.0021		0.15									
U ₃		0.049		0.00033		0.0042		0.0017		0.00059		0.039									
Certified		22.5		0.0011		0.33		0.079		0.0081		15.2									
Uncertainty		0.2		0.0004		0.02		0.005		0.0008		0.1									
Tolerance		0.6		0.0010		0.06		0.015		0.0024		0.3									

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* Code for method

Informational values listed as weight percent

Analysis	*	As	*	B	*	Cu	*	Mg	*	P	*	S	*	Ta	*	Zr
1	9	0.00007	12	0.00064333	10	0.011	5	0.00047667	12	0.0015	12	0.000037	5	0.0034	5	0.0011
2	12	0.00033	5	0.0017	12	0.01233333	12	0.00052667	5	0.0020667	1	0.000227	5	0.00363	5	0.00111
3	4	0.0003333	4	0.0024	3	0.013	5	0.00053333	7	0.0050533	1	0.0003	5	0.00375	12	0.0012
4	15	0.0006167	4	0.00313333	5	0.01456667	4	0.00087667	5	0.00512	1	0.000375	12	0.00487	5	0.00123
5	4	0.2555333	5	0.00330	8	0.0148	4	0.001	3	0.0055	1	0.00042	4	0.0181	3	0.008
6			7	0.00355667	5	0.0151	14	0.00136667	4	0.0065	3	0.0006	4	0.02023	4	0.0089
7			11	0.0042	5	0.01536667	3	0.0014	4	0.0068433	11	0.0006	11	0.021	10	0.010
8			14	0.00476667	4	0.0195	4	0.0018	10	0.0079	1	0.001	14	0.02103	4	0.02227
9	4	0.0048	4	0.0048	11	0.0199			11	0.0086	1	0.0012	4	0.02417	3	0.0226
10			4	0.0048	4	0.02213333			4	0.0096	1	0.0017	3	0.027		
11			3	0.005	4	0.02246667			4	0.0103667	3	0.0034				
12			3	0.005	14	0.02293333			4	0.0105667						
13			4	0.0051	4	0.02366667			14	0.0109667						
14			3	0.00524	3	0.025			4	0.011						
15			4	0.00583333	10	0.02631			10	0.0118333						
16					3	0.028										
17					10	0.037										
Average		0.05		0.004		0.0202		0.0010		0.0075		0.0009		0.01		0.01
Std Dev		0.47		0.018		0.0068		0.0026		0.0033		0.0018		0.11		0.12
H		0.0021		0.001		0.0015		0.0004		0.00091		0.0004		0.001		0.001
U ₁		0.47		0.018		0.0016		0.0026		0.041		0.0019		0.11		0.12
t-statistic		2.78		2.14		2.12		2.36		2.14		2.23		2.26		2.31
U ₂		1.32		0.038		0.0034		0.0062		0.089		0.0041		0.25		0.28
U ₃		0.59		0.0097		0.00083		0.0022		0.023		0.0012		0.079		0.095
Information:		(0.05)		(0.004)		(0.02)		(0.001)		(0.008)		(0.0009)		(0.01)		(0.008)

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. 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.

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* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ag	*	Ba	*	Ce	*	Ga	*	Ge	*	Ir	*	Li	*	Nd	*	Os	*	Pb
1	12	0.5	12	0.48	12	0.31	12	11	12	0.14	12	0.03	12	0.006	12	0.09	12	0.01	12	0.52
2	12	0.55	12	0.68	12	0.46	12	11	12	0.16	12	0.06	12	0.006	12	0.14	12	0.03	12	0.69
3	12	0.63	12	0.73	12	0.46	12	11	12	0.2	12	0.11			12	0.14	12	0.06	12	0.75
Analysis	*	Pr	*	Re	*	Sb	*	Sn	*	Tl	*	U	*	Zn						
1	12	0.03	12	1.1	12	0.32	12	2.4	12	0.08	12	0.44	12	1.5						
2	12	0.03	12	1.3	12	0.38	12	2.9	12	0.08	12	0.65	12	1.5						
3	12	0.03	12	1.5	12	0.38	12	3	12	0.09	12	0.71	12	1.6						

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	18 Wet

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: 112X14360, 112X14930, 24X26310, 24XWASP40; AR 164, 512, 654, 662, 668, 670, 673, 675, 876, 882, 892, 1648, 1652, 1653; BAM 321-1; BS HON U, 171, 171A, 171B, 172, 172A; DSZU CA01A; ECRM 299-1, 327-2; IARM 62E, 64C, 96B, 96C, 96D, 97A, 97B, 97C, 98B, 207A, 208B, 241A; 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, 502-869, 502-904, 502-916; SRM 15G, 33D, 36, 168, 862, 1199, 1200, 1242, 1413, 3103A.

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, 171, 171A, 171B, 172; DSZU CA01A; ECRM 299-1; IMZ 186; LECO 501-676, 502-916; SRM 1199, 1200, 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 172B 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 VDM Metals USA, LLC; Reno, NV

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 172B-080619. 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:

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Houston, Texas 77069-2895 USA

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

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Revision: This certified reference material was originally certified as a reference material on August 6, 2019. On April 3, 2024 the standard deviation was recalculated for Co, Cr, Cu, Nb, Ni, P, and Ti. This is reflected on pages 2-3. No other portion of this certificate has changed.

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 April 3, 2024.

Beau R. Brammer
President