

Brammer Standard Company, Inc.

Certificate of Analysis

BS CD4MCU

Certified Reference Material for High Alloy Steel - UNS Number J93370

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0063	0.0006		N	0.004
As	0.0040	0.0005		Ni	0.08
B	0.0028	0.0004		O	0.001
C	0.045	0.001		P	0.002
Cr	24.46	0.08		S	0.001
Cu	2.93	0.04		Si	0.01
Fe	63.2	0.2		Ti	0.002
Mn	0.568	0.009		V	0.002
Mo	1.98	0.03		W	0.002

Informational Values^{3,4}

Ca (0.001)	Co (0.03)	Mg (0.0003)	Nb (0.004)	Pb (0.0009)
Sn (0.03)	Zn (0.01)	Zr (0.002)		

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, Bi, Ce, Cl, Ga, Ge, In, Ir, K, Na, Os, Re, Ru, Sb, Se, Sr, Ta, Te, and Y 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.

Analysis	*	Al	*	As	*	B	*	C	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N
1	3	0.005	9	0.003267	4	0.0020	1	0.0428	4	24.3	3	2.80	14	63.1	4	0.54	4	1.96667	2	0.21903
2	5	0.00563333	5	0.003367	4	0.002433333	3	0.0431	11	24.3833	4	2.86	16	[63.1]	8	0.544333	4	1.96853	2	0.227
3	3	0.0057	5	0.0034	4	0.0025	1	0.04317	3	24.39	3	2.86	16	[63.162567]	4	0.550333	4	1.96867	2	0.22776
4	14	0.00573333	15	0.003843	14	0.002533333	11	0.04373	14	24.4	10	2.882	11	63.19	4	0.559333	3	1.9700	2	0.22833
5	4	0.006	5	0.003867	3	0.0026	1	0.04377	4	24.4	3	2.9106	16	[63.2]	4	0.5595	4	1.9857	2	0.2290
6	4	0.00622	4	0.004	3	0.0027	1	0.04447	13	24.405	4	2.920333	16	[63.202]	4	0.5644	4	1.987	2	0.229
7	4	0.0064	11	0.004133	4	0.0028	1	0.0445	4	24.4613	4	2.924167	4	63.2166667	4	0.565033	4	1.98787	2	0.2308
8	4	0.0064	4	0.004333	5	0.00291	1	0.04473	17	24.4846	4	2.925333	11	63.3533333	3	0.567	11	1.99667	2	0.2334
9	11	0.00646667	11	0.0044	4	0.002966667	3	0.045	11	24.49	4	2.942667	16	[63.3567]	3	0.57	11	2	2	0.2339
10	4	0.00683333	12	0.004433	4	0.003033333	3	0.0456	10	24.49	4	2.956333	13	63.394	4	0.570333	10	2.002	3	0.236
11	3	0.0070	4	0.0047	7	0.003046667	1	0.04567	3	24.5238	11	2.96			10	0.571	3	2.01		
12					5	0.0035	1	0.0459	13	24.5313	4	2.9675			11	0.576667	10	2.01		
13							11	0.0462	4	24.5367	4	2.97			11	0.577	14	2.01333		
14							1	0.04733	10	24.555	4	2.9742			4	0.577667				
15							1	0.048	4	24.6527	10	2.98			14	0.585333				
16							1	0.04833			14	3.003333			4	0.5855				
17											11	3.01			10	0.59				
Average		0.00628		0.00404		0.002849		0.0447		24.4613		2.932145		63.218		0.567849		1.9803		0.2293
Std Dev		0.00022		0.00012		0.000091		0.0013		0.0038		0.000077		0.063		0.000077		0.0068		0.0043
H		0.00080		0.00067		0.00058		0.0019		0.084		0.020		0.17		0.0075		0.016		0.0045
U ₁		0.00083		0.00068		0.00059		0.0024		0.084		0.020		0.18		0.0075		0.017		0.0062
t-statistic		2.23		2.23		2.20		2.13		2.14		2.12		2.26		2.12		2.18		2.26
U ₂		0.0018		0.0015		0.0013		0.0050		0.18		0.043		0.40		0.016		0.037		0.014
U ₃		0.00056		0.00046		0.00037		0.0013		0.047		0.010		0.13		0.0038		0.010		0.0044
Certified		0.0063		0.0040		0.0028		0.045		24.46		2.93		63.2		0.568		1.98		0.229
Uncertainty		0.0006		0.0005		0.0004		0.001		0.08		0.04		0.2		0.009		0.03		0.004
Tolerance		0.0018		0.0015		0.0013		0.005		0.24		0.12		0.6		0.027		0.09		0.014

Analysis	*	Ni	*	O	*	P	*	S	*	Si	*	Ti	*	V	*	W
1	3	5.5333	2	0.016533	5	0.020966667	1	0.0181	6	0.69267	4	0.0192	3	0.105	5	0.0217
2	4	5.53633333	2	0.017467	11	0.0217	1	0.01823	4	0.696	4	0.019467	4	0.106	5	0.021967
3	4	5.56866667	2	0.017933	5	0.022633333	1	0.01893	4	0.69867	11	0.019667	11	0.106	4	0.0227
4	4	5.57066667	2	0.0183	4	0.023166667	1	0.0200	17	0.70037	5	0.019867	3	0.1069	4	0.022967
5	13	5.58033333	2	0.018367	11	0.0235	1	0.02003	4	0.70813	4	0.020033	3	0.107	12	0.023267
6	4	5.58333333	2	0.0188	14	0.023766667	3	0.0209	10	0.71	3	0.0201	10	0.107	4	0.024
7	4	5.58616667	2	0.018893	4	0.0240	1	0.02093	3	0.71	4	0.020233	4	0.107	11	0.0241
8	14	5.59333333	2	0.01986	3	0.0245	1	0.02097	11	0.71033	11	0.0203	4	0.10706667	4	0.024333
9	4	5.6087	2	0.0200	7	0.024566667	3	0.021	3	0.7141	4	0.020333	4	0.10733333	4	0.024667
10	3	5.61	2	0.024667	3	0.025	10	0.0212	4	0.71433	9	0.020767	11	0.10766667	4	0.0249
11	10	5.623			4	0.025333333	1	0.02123	6	0.71917	3	0.021	4	0.109	11	0.025733
12	10	5.63			10	0.0255	11	0.022	11	0.721	4	0.022067	4	0.109	14	0.0261
13	4	5.640			4	0.0262	11	0.022	9	0.72233	5	0.0229	4	0.110	4	0.0261
14	3	5.66			3	0.0265	3	0.0229	4	0.7270	7	0.023067	10	0.11	3	0.0286
15	11	5.7			4	0.027266667	1	0.0233	6	0.72767	4	0.0237	4	0.1103		
16	11	5.70666667			4	0.0274			10	0.024	14	0.11166667				
17	4	5.7267			4	0.0319										
18	4	5.78														
Average		5.624289		0.01853		0.02497		0.02078		0.7149		0.02095		0.1080		0.02447
Std Dev		0.000075		0.00085		0.00082		0.00071		0.0045		0.00075		0.0023		0.00083
H		0.031		0.0013		0.0015		0.0013		0.00855		0.001353		0.0030		0.0015
U ₁		0.031		0.0015		0.0017		0.0015		0.0097		0.0015		0.0038		0.0017
t-statistic		2.11		2.26		2.12		2.14		2.14		2.13		2.13		2.16
U ₂		0.065		0.0035		0.0036		0.0033		0.021		0.0033		0.0081		0.0036
U ₃		0.015		0.0011		0.00086		0.00084		0.0054		0.00083		0.0020		0.0010
Certified		5.62		0.019		0.025		0.021		0.71		0.021		0.108		0.024
Uncertainty		0.08		0.001		0.002		0.001		0.01		0.002		0.002		0.002
Tolerance		0.24		0.003		0.006		0.003		0.03		0.006		0.008		0.006

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* Code for method

Informational values listed as weight percent

Analysis	*	Ca	*	Co	*	Mg	*	Nb	*	Pb	*	Sn	*	Zn	*	Zr
1	12	0.0001173	11	0.023867	12	0.00000367	5	0.0005	9	0.0002	11	0.0156	5	0.005167	5	0.0001
2	11	0.00026667	5	0.025333	4	0.00021	5	0.00057	5	0.0002	14	0.017967	5	0.007967	5	0.000193
3	11	0.0003	4	0.027433	4	0.000296667	5	0.00069	3	0.0002	11	0.0204	5	0.009663	12	0.000433
4	3	0.00034	4	0.027567	3	0.00031	12	0.00088	4	0.00035	4	0.021267	4	0.009933	4	0.001767
5	4	0.00276667	4	0.028	4	0.000466667	4	0.0052	5	0.00046	3	0.025	12	0.013667	3	0.0019
6	14	0.00286667	5	0.0284			11	0.00537	5	0.0005	4	0.0267	14	0.015467	4	0.0023
7	4	0.00306667	11	0.0302			11	0.0056	12	0.00062	12	0.028667			4	0.0031
8			4	0.030533			4	0.0057	5	0.00067	5	0.028733			4	0.003267
9			4	0.031033			14	0.00613	4	0.0008	3	0.0299			3	0.0036
10			4	0.031933			3	0.0062	3	0.0046	5	0.030867			3	0.0039
11			3	0.0339			4	0.0068			4	0.0314				
12			10	0.034			4	0.0089			4	0.033				
13			4	0.0344							4	0.0362				
14			12	0.034667												
15			14	0.037367												
Average		0.0014		0.03		0.00026		0.004		0.0009		0.03		0.010		0.0021
Std Dev		0.0049		0.18		0.00022		0.023		0.0018		0.17		0.095		0.0079
H		0.0004		0.002		0.00025		0.001		0.0004		0.002		0.001		0.0005
U ₁		0.0049		0.18		0.00034		0.023		0.0018		0.17		0.095		0.0080
t-statistic		2.45		2.14		2.78		2.20		2.26		2.18		2.57		2.26
U ₂		0.012		0.39		0.00093		0.050		0.0041		0.38		0.25		0.018
U ₃		0.0045		0.10		0.00042		0.014		0.0013		0.10		0.010		0.0057
Informational		(0.001)		(0.03)		(0.0003)		(0.004)		(0.0009)		(0.03)		(0.01)		(0.002)

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	*	Bi	*	Ce	*	Cl	*	Ga	*	Ge	*	In	*	Ir	*	K	*	Na
1	12	3.2	12	1.6	12	0.006	12	0.02	12	15	12	5.2	12	0.07	12	0.19	12	0.05	12	0.01
2	12	3.4	12	1.8	12	0.008	12	0.02	12	15	12	5.4	12	0.10	12	0.20	12	0.11	12	0.01
3	12	3.4	12	1.8	12	0.009	12	0.03	12	15	12	5.6	12	0.13	12	0.22				
Analysis	*	Os	*	Re	*	Ru	*	Sb	*	Se	*	Sr	*	Ta	*	Te	*	Y		
1	12	0.16	12	2.8	12	0.02	12	9.6	12	1.1	12	0.16	12	1.1	12	0.65	12	0.02		
2	12	0.17	12	2.9	12	0.02	12	10	12	1.2	12	0.16	12	1.1	12	0.70	12	0.02		
3	12	0.18	12	2.9	12	0.04	12	10	12	1.2	12	0.18	12	1.2	12	0.70	12	0.02		
4									3	101			4	27						

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 WET
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
Exova	Glendale Heights, IL	A2LA	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Luvak Inc.	Boylston, MA	PRI	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	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: 13XPH2M, 13XPH4N, 13XPH7F; AR 512, 644, 646, 654, 657, 662, 675, 676, 882, 892, 950, 956, 1647, 1648, 1652, 1653; BAS 431, 464/1, 475; BS HON-U, 17-4PHA, 30D, 56H, 75G, 88C, 88E, 179, 179A, 179B, 179C, 179D, 180B, 185, 185A, 303, 2205; ECRM 151-1; IARM 2C, 3B, 4C, 5F, 16C, 21C, 22B, 163A, 164, 212B, 212C, 212D, 234B, 239A, 239B, 239C, 301A, 302A; JK 37; LECO 501-320, 501-504, 501-644, 501-646, 501-674, 501-676, 502-195, 502-868, 502-887, 502-904, 502-916, 502-928; NCS NS 11019, NS 21006; SRM C2401, 10G, 15G, 55D, 101A, 101C, 160B, 339, 345, 361, 362, 363, 369, 1155A, 3109A, 3131A, 3168A.

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 — BAS 475; BS HON-U, 88C, 88E, 179, 179B, 179C, 185, 2205; ECRM 151-1; LECO 501-676, 502-887; NCS NS 110019, NS 21006; SRM C2401, 101G, 339.

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 CD4MCU 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 cast stock for this CRM was produced by SPL-LABMAT s.r.o; Bohumin, CZ.

Form: This CRM is machined in the form of a disc, approximately 36 mm in diameter and 26 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 CD4MCU-061919. 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 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 June 19, 2019.

Beau R. Brammer
President