

Brammer Standard Company, Inc.

Certificate of Analysis

BS 6418

Certified Reference Material for AISI Steel Grade 6418 - UNS Number K32550

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values ³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.029	0.003	Mn	1.41	0.05
B	0.0004	0.0002	Mo	0.42	0.02
C	0.255	0.004	N	0.007	0.001
Ca	0.0002	0.0001	Nb	0.0022	0.0007
Co	0.010	0.001	Ni	1.74	0.05
Cr	0.34	0.01	O	0.0011	0.0002
Cu	0.109	0.003	S	0.0041	0.0006
Fe	[94.1]	0.2	Si	1.54	0.03
Mg	0.0004	0.0002	Ti	0.0036	0.0006

	Reference Value ¹	Estimate of Uncertainty ²	Reference Values ^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
As	0.004	0.002	Ta	<0.05	
P	0.010	0.002	V	0.003	0.001
Pb	<0.005		W	<0.05	
Sb	0.003	0.002	Zr	<0.005	
Sn	0.006	0.001			

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.

Trace element information values for 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.

Analysis	*	Al	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mg	*	Mn
1	4	0.0248	3	0.0003	1	0.25	4	0.0001	17	0.00885	3	0.33	3	0.104	16	[94.08]	3	0.0001	4	1.32
2	17	0.02585	3	0.0003	1	0.250	3	0.00018	3	0.009	4	0.33	17	0.108	16	[94.1]	11	0.0002	6	1.36
3	3	0.026	11	0.0005	3	0.251	3	0.0002	4	0.009	4	0.3335	4	0.108	16	[94.11]	4	0.00023	4	1.39
4	4	0.027	4	0.00065	1	0.251667	4	0.00023	4	0.00915	17	0.338	11	0.108	16	[94.13]	3	0.0005	17	1.3925
5	4	0.0271			1	0.251667	11	0.0003	11	0.0093	3	0.338	4	0.108	16	[94.15]	3	0.0009	3	1.4
6	4	0.028			11	0.254	3	0.0003	11	0.0098	3	0.339	11	0.109					11	1.41
7	3	0.0286			1	0.254	11	0.0003	4	0.010	4	0.34	4	0.11					4	1.41
8	4	0.029			1	0.254	4	0.0004	3	0.0104	11	0.341	4	0.11					11	1.42
9	11	0.0297			11	0.254			3	0.0106	4	0.342	4	0.11					4	1.42
10	3	0.0298			1	0.254			4	0.011	11	0.342	4	0.11					3	1.42
11	11	0.0306			1	0.258			4	0.011	4	0.346	3	0.111					3	1.42
12	4	0.032			3	0.258			4	0.0111	4	0.35	3	0.115					4	1.43
13	4	0.034			3	0.259			4	0.014	4	0.35	4	0.12					4	1.45
14					1	0.264													4	1.458
Average		0.028650		0.00035		0.2546		0.000234		0.010246		0.339962		0.1090		94.114		0.00039		1.407179
Std Dev		0.000088		0.00014		0.0040		0.000082		0.000088		0.000088		0.0028		0.045		0.00014		0.000085
H		0.0017		0.00029		0.0051		0.00026		0.0011		0.0060		0.0033		0.19		0.00030		0.013
U ₁		0.0017		0.00032		0.0065		0.00027		0.0011		0.0060		0.0044		0.19		0.00033		0.013
t-statistic		2.18		3.18		2.16		2.36		2.18		2.18		2.18		2.78		2.78		2.16
U ₂		0.0038		0.0010		0.014		0.00063		0.0024		0.013		0.0095		0.53		0.00093		0.028
U ₃		0.0011		0.00052		0.0038		0.00022		0.00066		0.0036		0.0026		0.24		0.00042		0.0076
Certified		0.029		0.0004		0.255		0.0002		0.010		0.34		0.109		[94.1]		0.0004		1.41
Uncertainty		0.003		0.0002		0.004		0.0001		0.001		0.01		0.003		0.2		0.0002		0.05
Tolerance		0.009		0.0003		0.014		0.0001		0.003		0.03		0.009		0.5		0.0003		0.15

Analysis	*	Mo	*	N	*	Nb	*	Ni	*	O	*	S	*	Si	*	Ti
1	4	0.38	2	0.0063	4	0.00073	4	1.71	2	0.0010	1	0.0030	4	1.47	4	0.002
2	3	0.393	2	0.0065	3	0.0021	17	1.727	2	0.0010	1	0.0031	6	1.51	17	0.003
3	17	0.4082	2	0.0067	3	0.0022	11	1.73	2	0.00112	1	0.003533	3	1.51	11	0.0033
4	6	0.41	2	0.0069	11	0.0028	11	1.73	2	0.0012	11	0.004	11	1.52	4	0.00335
5	3	0.414	2	0.007	11	0.0031	3	1.73			11	0.004	4	1.52	4	0.0034
6	4	0.419	2	0.007233			3	1.73			1	0.004	3	1.52	3	0.0036
7	4	0.42					4	1.73			1	0.004	11	1.52	4	0.0036
8	4	0.424					4	1.73			1	0.004	6	1.53	3	0.0037
9	4	0.43					17	1.73			3	0.0042	4	1.54	11	0.0038
10	11	0.432					4	1.74			1	0.0043	4	1.54	4	0.004
11	11	0.433					3	1.74			3	0.0043	4	1.54	4	0.004
12	3	0.434					4	1.755			1	0.0043	6	1.5475	3	0.005
13	4	0.44					4	1.77			3	0.006	3	1.55		
14	4	0.442					6	1.79					17	1.5565		
15													4	1.557		
16													4	1.56		
17													4	1.61		
Average		0.419943		0.00723		0.00219		1.7359		0.0011		0.004056		1.535353		0.003563
Std Dev		0.000085		0.00063		0.00014		0.0081		0.0042		0.000088		0.000077		0.000091
H		0.0067		0.0009		0.00058		0.015		0.0004		0.00074		0.014		0.00070
U ₁		0.0067		0.0011		0.00059		0.017		0.0042		0.00074		0.014		0.00071
t-statistic		2.16		2.57		2.78		2.16		3.18		2.18		2.12		2.20
U ₂		0.014		0.0029		0.0016		0.036		0.013		0.0016		0.029		0.0016
U ₃		0.0039		0.0012		0.00074		0.010		0.0067		0.00045		0.0071		0.00045
Certified		0.42		0.007		0.0022		1.74		0.0011		0.0041		1.54		0.0036
Uncertainty		0.02		0.001		0.0007		0.05		0.0002		0.0006		0.03		0.0006
Tolerance		0.06		0.003		0.0021		0.15		0.0006		0.0018		0.09		0.0018

Analysis	*	As	*	P	*	Pb	*	Sb	*	Sn	*	Ta	*	V	*	W	*	Zr
1	4	0.002	4	0.008	3	0.000062	11	0.0002	4	0.005	4	0.0020	4	0.0016	11	0.0002	11	0.000025
2	3	0.0037	3	0.0081	17	0.000079	4	0.00185	3	0.0053	11	0.0207	4	0.002	3	0.0005	11	0.002
3	3	0.004	3	0.0081	11	0.0001	4	0.002	3	0.0054	11	0.0345	4	0.0022	3	0.001	3	0.002
4	4	0.00425	11	0.0088	11	0.0002	3	0.003	4	0.00595			17	0.0025	11	0.003	3	0.002
5	17	0.00425	11	0.0089	3	0.0006	3	0.0041	3	0.006			4	0.003				
6	4	0.0044	4	0.0099	4	0.0008	3	0.0051	4	0.0066			11	0.0036				
7	9	0.0046	3	0.01	4	0.0020			4	0.0066			3	0.0036				
8	3	0.006	4	0.010	4	0.002			9	0.0068			11	0.0036				
9	4	0.006	4	0.0103					4	0.007			3	0.0038				
10			4	0.012					4	0.008			3	0.004				
11			4	0.015														
Average		0.00436		0.009918		0.00073		0.00189		0.00627		0.02		0.00299		0.0005		0.00175
Std Dev		0.00011		0.000095		0.00011		0.00064		0.00010		0.26		0.00010		0.0020		0.00096
H		0.00076		0.0011		0.00038		0.00054		0.00089		0.00		0.00065		0.0003		0.0005
U ₁		0.00077		0.0011		0.00040		0.00084		0.00089		0.26		0.00066		0.0020		0.0011
t-statistic		2.31		2.23		2.36		2.57		2.26		4.30		2.26		3.18		3.18
U ₂		0.0018		0.0024		0.00094		0.0021		0.0020		1.13		0.0015		0.0064		0.0035
U ₃		0.00059		0.00073		0.00033		0.00088		0.00064		0.65		0.00047		0.0032		0.0017
Reference		0.004		0.010		<0.005		0.003		0.006		<0.05		0.003		<0.05		<0.005
Uncertainty		0.002		0.002				0.002		0.001				0.001				
Tolerance		0.003		0.006				0.002		0.003				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 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.

Analysis	*	Zn
1	4	23
2	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 AAS
6 Gravimetric	12 GD Mass Spectrometry	

ICP = Inductively Coupled Plasma GF = Graphite Furnace GD = Glow Discharge
 DCP = Direct Current Plasma HG = Hydride Generation AAS = Atomic Absorption Spectrometry

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
LECO Corporation	St. Joseph, MI	A2LA	17025
Crucible Specialty Metals	Syracuse, NY		
Dirats Laboratories	Westfield, MA	ANAB	17025
VHG Labs	Manchester, NH	A2LA	17025
Analytical Associates	Detroit, MI		
Coleman Testing Laboratories	n/a		
The Timken Company	n/a		
Laboratory Testing, Inc.	Hatfield, PA	PRI	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 a lathe 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: AR 644; BAM 039-2, 044-1; BAS 345, 346, 451, 455/1, 456/1, 457/1, 458/1; BS CSN-1, CSN-2, CSN-4, LAS 1, 11A, 12, 13, 14A, 36A, 50D, 54D, 69A, 300, 300A, 1763, 3021, 3022, 4340M; CKD CZ 2005A, 165D, 170H, 183A, 186A; ECRM 085-1, 088-1, 096-1, 184-1, 186-1, 191-1, 481/1; IMZ 1.8/4, 1.22, 1.74; JSS 169-4, 170-6, 171-4; LECO 501-501, 501-503, 501-504, 501-505, 501-506, 501-510, 501-553, 501-644, 502-016, 502-052; NCS NS 11007, 11079; SRM C1173, 13G, 32E, 36B, 82B, 100B, 122F, 125B, 293, 342A, 344, 361, 362, 363, 364, 364, 1256, 1261A, 1262A, 1263A, 1264A, 1265A, 1761, 1762, 1763, 1764, 1765, 1767, 1966, 2171, 3103, 3106, 3149, 3165.

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 69A, 300, 300A, 1763, 3021, 3022, 4340M; CKD 183A, 186A; SRM 1763.

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 6418 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 Copperweld Steel Company, Warren, Ohio.

Form: This CRM is machined in the form of a disc, approximately 57mm 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 REV6418-032323. 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

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Fax: (281) 440-4432

Web: www.brammerstandard.com
Email: contact@brammerstandard.com

Revision: This certified reference material was originally certified as a reference material on February 1, 1995. A comprehensive homogeneity study, including additional information about its contribution to the uncertainty estimates, was performed. The elements B, Ca, Fe, Mg, Nb, and O have been added to the certified list. As, P, Sn, and V have been changed from certified to reference. Pb, Sb, Ta, W, and Zr have been added to the reference list. Revised values for all elements except Co are presented. All trace data are presented in mg/kg (ppm).

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 17025:2017 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 35:2017 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 March 23, 2023.

Beau R. Brammer

President