

Brammer Standard Company, Inc.

Certificate of Analysis

BS 1018A

Certified Reference Material for AISI 1018 - UNS Number G10180

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values ³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0199	0.0009	N	0.0061	0.0006
As	0.0040	0.0007	Nb	0.0012	0.0004
B	0.0003	0.0002	Ni	0.092	0.004
C	0.192	0.009	P	0.0078	0.0009
Ca	0.0008	0.0003	Pb	0.0005	0.0003
Co	0.0062	0.0004	S	0.020	0.002
Cr	0.094	0.004	Sb	0.0012	0.0004
Cu	0.134	0.007	Si	0.197	0.007
Fe	98.5	0.1	Sn	0.0075	0.0009
Mg	0.0002	0.0001	Ti	0.0006	0.0003
Mn	0.73	0.03	V	0.0019	0.0007
Mo	0.035	0.003	Zr	0.0011	0.0003

	Reference Value ¹	Estimate of Uncertainty ²	Reference Values ^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
H	<0.005		Ta	0.003	0.002
O	0.0015	0.0009	W	0.0004	0.0003

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 4 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 4 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.

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	Ca	Co	Cr	Cu	Fe	Mg
1	4 0.0187	4 0.00333	3 0.000060	1 0.1756667	4 0.0006467	4 0.0056333	3 0.09	3 0.13	16 [98.396]	5 0.0001167
2	4 0.0187333	9 0.00367	5 0.000097	1 0.1833333	4 0.0008333	11 0.0059	4 0.091467	10 0.13	16 [98.42]	4 0.0001333
3	5 0.0190	4 0.00373	5 0.0001	1 0.187	3 0.0009	4 0.00591	4 0.0928	8 0.13	16 [98.4211]	4 0.0002
4	3 0.019	3 0.0038	5 0.0001333	1 0.1873333	11 0.0009	7 0.0059333	3 0.0929	3 0.13	16 [98.42733]	3 0.0002
5	11 0.0194	5 0.00383	11 0.0002	1 0.1873333	4 0.0009333	10 0.006	4 0.093333	7 0.131	4 98.43	4 0.0003633
6	3 0.0195	10 0.004	4 0.0002	1 0.1889	4 0.00096	8 0.006	4 0.093633	5 0.131	16 [98.45]	
7	4 0.0198667	4 0.0040		1 0.19	4 0.0009667	3 0.006	5 0.093833	4 0.1313333	16 [98.45]	
8	4 0.0199	5 0.00407		1 0.19	4 0.0010667	4 0.0060	10 0.094	3 0.132	10 98.45	
9	4 0.0199333	5 0.00421		3 0.1900		5 0.0060333	3 0.094	4 0.1323333	3 98.46	
10	3 0.02	5 0.00457		1 0.1926667		3 0.0061	4 0.094367	3 0.133	16 [98.46]	
11	3 0.020			1 0.193		14 0.0061	4 0.094433	4 0.1336	16 [98.472334]	
12	4 0.0200			11 0.195		5 0.0061	11 0.0945	4 0.134	16 [98.49667]	
13	4 0.020			3 0.195		4 0.0063667	10 0.0947	4 0.136	14 98.50	
14	4 0.0200667			1 0.1976667		4 0.0065	3 0.095	11 0.136		
15	14 0.0205667			1 0.1988667		4 0.0065	8 0.096	10 0.136		
16	10 0.0208333			1 0.1991333		4 0.0065333	4 0.0960	14 0.136		
17	10 0.021			3 0.21		3 0.0067	14 0.096133	4 0.1360667		
18	5 0.0213					3 0.007	4 0.0966	4 0.1368667		
19							10 0.097	10 0.1373333		
20							3 0.097667	4 0.139		
21								4 0.14		
22								3 0.143333		
Average	0.01995	0.00400	0.000132	0.1921	0.000831	0.00618	0.0939	0.1343	98.453	0.00020
Std Dev	0.00065	0.00019	0.000058	0.0031	0.00063	0.00034	0.0021	0.0037	0.018	0.00010
H	0.0015	0.00073	0.00020	0.0044	0.00040	0.00088	0.0031	0.0037	0.19	0.00024
U ₁	0.0016	0.00076	0.00023	0.0054	0.00040	0.00088	0.0037	0.0037	0.19	0.00028
t-statistic	2.11	2.26	2.57	2.12	2.36	2.11	2.09	2.08	2.18	2.78
U ₂	0.0034	0.0017	0.00060	0.011	0.0010	0.0019	0.0078	0.0077	0.42	0.00078
U ₃	0.00080	0.00054	0.00024	0.0028	0.00034	0.00044	0.0017	0.0016	0.12	0.00035
Certified	0.0199	0.0040	0.0003	0.192	0.0008	0.0062	0.094	0.134	98.5	0.0002
Uncertainty	0.0009	0.0007	0.0002	0.009	0.0003	0.0004	0.004	0.007	0.1	0.0001
Tolerance	0.0027	0.0021	0.0002	0.027	0.0007	0.0012	0.012	0.021	0.3	0.0001

Analysis	Mn	Mo	N	Nb	Ni	P	Pb	S	Sb	Si
1	4 0.7046667	3 0.03	2 0.00545	11 0.0002	4 0.0853667	5 0.0067	3 0.0003	3 0.018	4 0.000933333	3 0.19
2	7 0.7163333	4 0.030	2 0.0055333	4 0.0008	5 0.0871333	4 0.0069367	11 0.0004	1 0.0183333	5 0.001056667	3 0.19
3	3 0.7193333	3 0.0329	2 0.0056967	4 0.0009	4 0.0892333	11 0.007	5 0.000433	1 0.0184	5 0.0011	4 0.1927333
4	10 0.72	4 0.0344	2 0.0058	5 0.0012267	7 0.0892333	3 0.007	5 0.0005	1 0.0186667	5 0.001133333	4 0.1933333
5	3 0.72	10 0.035	2 0.0060667	5 0.0013	4 0.0893333	3 0.007	5 0.0005	1 0.01874	5 0.0013	4 0.1935
6	10 0.72	3 0.035	2 0.0060667	5 0.0014	4 0.0897	4 0.00735	9 0.0005	4 0.0189667	9 0.0014	3 0.1943333
7	3 0.723	4 0.035167	2 0.0061667	3 0.0014	8 0.09	4 0.0075333	5 0.000673	10 0.019	3 0.0016	7 0.1943333
8	10 0.7266667	10 0.035167	2 0.0062767	4 0.0023	3 0.09	14 0.0076333		1 0.0192		3 0.196
9	14 0.7266667	4 0.035433	2 0.0063		3 0.090	10 0.008		1 0.0194		14 0.1976667
10	4 0.727	4 0.0357	2 0.0063267		10 0.090	4 0.008		3 0.0197		4 0.198
11	4 0.728	5 0.035833	2 0.0067333		11 0.091	3 0.0080		1 0.02		4 0.1989
12	4 0.7285667	11 0.0359			3 0.091	10 0.0080		3 0.0200		11 0.199
13	4 0.7287	4 0.0360			3 0.092	3 0.0082333		11 0.0202		10 0.20
14	3 0.73	10 0.036			3 0.092	4 0.0083667		10 0.0208		3 0.20
15	4 0.7300333	3 0.036167			4 0.092	3 0.0084		1 0.0209		4 0.200
16	4 0.7311333	4 0.0364			10 0.0924333	4 0.0084667		1 0.0209		4 0.2000
17	11 0.733	4 0.037267			4 0.0925	4 0.0085				4 0.2008333
18	3 0.74	4 0.037367			4 0.0933	4 0.0085667				10 0.2013333
19	4 0.7426667	8 0.038			14 0.0937667					5 0.2016667
20	8 0.75	14 0.0382			4 0.0939667					4 0.2026667
21	4 0.753667				4 0.095467					
22					7 0.097					
Average	0.729	0.0348	0.00605	0.001158	0.0917	0.00776	0.000459	0.01945	0.001155	0.1972
Std Dev	0.011	0.0010	0.00021	0.000096	0.0019	0.00063	0.000037	0.00094	0.000075	0.0039
H	0.0091	0.0019	0.00087	0.00045	0.0030	0.00097	0.00032	0.0015	0.00045	0.0045
U ₁	0.0091	0.0022	0.00090	0.00046	0.0036	0.00097	0.00032	0.0015	0.00046	0.0045
t-statistic	2.09	2.09	2.23	2.36	2.08	2.11	2.45	2.13	2.45	2.09
U ₂	0.019	0.0045	0.0020	0.0011	0.0074	0.0021	0.00079	0.0031	0.0011	0.0094
U ₃	0.0041	0.0010	0.00060	0.00038	0.0016	0.00048	0.00030	0.00078	0.00042	0.0021
Certified	0.73	0.035	0.0061	0.0012	0.092	0.0078	0.0005	0.020	0.0012	0.197
Uncertainty	0.03	0.003	0.0006	0.0004	0.004	0.0009	0.0003	0.002	0.0004	0.007
Tolerance	0.09	0.009	0.0018	0.0011	0.012	0.0027	0.0004	0.006	0.0011	0.021

BS 1018A * Code for method Certified values listed as weight percent

Analysis		Sn		Ti		V		Zr													
1	4	0.005		5	0.00047	14	0.0014333	5	0.0004733												
2	5	0.0073733		5	0.000533	11	0.0015	3	0.0009												
3	4	0.0074		4	0.000567	3	0.0017	4	0.0011												
4	5	0.0075667		11	0.0006	4	0.0018333	4	0.0011												
5	4	0.0076		5	0.000603	4	0.0019567	4	0.0011333												
6	9	0.0076667		14	0.000767	10	0.002	11	0.0018												
7	3	0.0077		4	0.000767	4	0.0020														
8	4	0.0078333		3	0.0008	4	0.0020														
9	10	0.008				4	0.00203														
10	3	0.0080				5	0.0021														
11	3	0.008				5	0.0021333														
12	4	0.008				4	0.0026														
13	5	0.0082				4	0.0026														
14	5	0.0082667																			
15	4	0.0084667																			
16	3	0.01																			
Average		0.00753			0.000566		0.001881		0.00108												
Std Dev		0.00026			0.000061		0.000099		0.00043												
H		0.00096			0.00035		0.00054		0.0003065												
U ₁		0.00099			0.00035		0.00055		0.00033												
t-statistic		2.13			2.36		2.18		2.5705818												
U ₂		0.0021			0.00083		0.0012		0.00085												
U ₃		0.00053			0.00029		0.00033		0.00035												
Certified		0.0075			0.0006		0.0019		0.0011												
Uncertainty		0.0009			0.0003		0.0007		0.0003												
Tolerance		0.0027			0.0005		0.0018		0.0009												

BS 1018A * Code for method Reference values listed as weight percent

Analysis		H		O		Ta		W													
1	2	0.000086		2	0.0007	5	0.0001167	11	0.000015												
2	2	0.0001		2	0.001067	14	0.0018	5	0.0003												
3	2	0.0001007		2	0.001167	4	0.0035333	5	0.0005233												
4	2	0.0003		2	0.001367	4	0.0040	4	0.0005333												
5	2	0.0004		2	0.001533	4	0.0040333	4	0.0006667												
6				2	0.001733	3	0.0058	5	0.00072												
7				2	0.002393			3	0.0009												
8				2	0.002433																
Average		0.00020			0.00155		0.0032		0.000401												
Std Dev		0.00014			0.00062		0.0020		0.000045												
H		0.00024			0.00050		0.00067		0.00031												
U ₁		0.00028			0.00052		0.00068		0.00031												
t-statistic		2.78			2.36		2.57		2.45												
U ₂		0.00078			0.0012		0.0018		0.00076												
U ₃		0.00035			0.00043		0.00072		0.00029												
Reference		<0.005			0.0015		0.003		0.0004												
Uncertainty					0.0009		0.002		0.0003												
Tolerance					0.0014		0.002		0.0003												

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.

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 | |
| 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
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Shiva Analyticals Private Limited	Hoskote, Bangalore	NABL	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Luvak Inc.	Boylston, MA	PRI	17025
Laboratory Testing, Inc.	Hatfield, PA	A2LA	17025
Raghavendra Spectro Metallurgical Laboratory	Karnataka, India	NABL	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
APL, Inc	Milwaukee, WI	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
 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: AR 414B, 555, 612B, 614A, 644, 645, 659, 662, 668, 673, 675, 867, 870, 871, 873, 889, 947, 1647, 1650, 1651, 1653; BAS 431, 464/1; BS XCAS, XCCS-2, 46B, 56H, 57D, 57F, 60E, 61G, 1011, 1018, 1020, 1026, 1026A, 1030A, 2001, 2023, 2931, 2931B, 3012, 4140C, 4330MOD, 4931, 4951; CKD CZ 2005A, 2025A; IARM 28I, 30C, 156A, 299A; IMZ 112; LECO 501-503, 502-060, 502-416, 502-503, 502-863, 502-913, 502-963, 502-978; NCS NS 11043; SRM 13F, 72F, 72G, 111B, 122H, 131E, 136B, 160B, 343A, 361, 362, 363, 364.

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 57D, 57F, 1011, 1018, 1026, 2001, 2931, 2931B, 301, 4951.

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 1018A 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 Niagara Lasalle Corporation; Hammond, IN.

Form: This CRM is machined in the form of a disc, approximately 38 mm 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 1018A-100124. 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
Fax: (281) 440-4432

Web: www.brammerstandard.com
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 (our current Certificate Number 656.02 expires 01/31/2025)

Brammer Standard Company's Chemical Laboratory is accredited by A2LA to ISO Standard 17025. (Our current Certificate Number 656.01 expires 01/31/2025)

By current Certificate Number 10539 expiring 01/01/2027, 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 October 1, 2024.

Beau R. Brammer

President