

Brammer Standard Company, Inc.

Certificate of Analysis

BS 1018

Certified Reference Material for AISI 1018 - UNS Number G10180

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.029	0.002		Ni	0.005
As	0.0041	0.0004		O	0.0005
C	0.195	0.005		P	0.001
Co	0.0058	0.0007		S	0.001
Cr	0.177	0.005		Si	0.007
Cu	0.130	0.004		Sn	0.0004
Fe	98.2	0.2		Ti	0.0004
Mn	0.79	0.01		V	0.0002
Mo	0.044	0.002		W	0.0005
N	0.0079	0.0005			

Informational Values^{3,4}

B (0.0002)	Ca (0.0004)	Mg (0.0003)	Nb (0.0006)	Pb (0.0006)
Sb (0.001)	Zr (0.001)			

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, Ce, Cl, Ga, Ge, K, La, Na, Nd, Re, Ta, 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.

Analysis	*	Al	*	As	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N
1	12	0.016	3	0.0035	1	0.1846	12	0.0047	17	0.17	12	0.0990	10	98.18334	12	0.68	12	0.0380	2	0.007
2	3	0.023	10	0.0037	1	0.189	8	0.00492	10	0.17	8	0.12233	16	[98.1839334]	3	0.77367	10	0.04	2	0.00744
3	10	0.027667	12	0.0037	1	0.19	14	0.0050667	3	0.171	4	0.124	16	[98.2]	8	0.77867	3	0.0423	2	0.00764
4	3	0.0278	10	0.003733	1	0.19	5	0.0051833	4	0.173	3	0.126	14	98.2	4	0.7798	10	0.042667	2	0.0077
5	5	0.0280667	4	0.0039667	1	0.1920	5	0.0054334	4	0.174	4	0.126333	4	98.2037	10	0.78	4	0.043	2	0.00784
6	3	0.028133	3	0.004	1	0.192	3	0.0056	4	0.17423	4	0.12667	16	[98.20667]	3	0.78	3	0.043	2	0.00793
7	4	0.0283	5	0.0040133	1	0.1923	4	0.005667	10	0.175	3	0.128667	16	[98.2133]	4	0.78033	10	0.043	2	0.0081
8	4	0.02833	4	0.0041667	1	0.195	4	0.0057667	10	0.175	4	0.13	16	[98.22333]	4	0.78133	4	0.0431	2	0.00813
9	4	0.02864667	5	0.0043	3	0.195	4	0.0058	4	0.176	4	0.13	17	98.223334	4	0.78267	5	0.0432	2	0.0086
10	10	0.029	4	0.0043667	3	0.196	10	0.0059	3	0.177	3	0.1300	3	98.224	10	0.78333	4	0.043633	2	0.00883
11	4	0.029533	12	0.0045	1	0.1961	3	0.006	7	0.17767	10	0.13	4	98.233	10	0.786	3	0.043667	2	0.0090
12	4	0.0299667	9	0.004667	1	0.19733	5	0.0063	4	0.1777	10	0.130	13	98.23667	17	0.78667	4	0.0438667		
13	4	0.03	5	0.00533	1	0.200	4	0.0063667	4	0.1798	14	0.130667	10	98.24	4	0.788	4	0.0442667		
14	4	0.030033			3	0.202	4	0.0064	3	0.18	3	0.131	4	98.24	3	0.79	4	0.044633		
15	14	0.030733			1	0.2038667	10	0.00667	4	0.18	4	0.132	16	[98.25]	4	0.79	10	0.0449		
16	4	0.0310			1	0.21	3	0.007	4	0.18	4	0.1325667	3	98.25	4	0.79167	3	0.045		
17	4	0.0318					12	0.007533	14	0.18067	10	0.132667			4	0.799	4	0.0463		
18	3	0.032					4	0.0077334	3	0.18233	4	0.1329			4	0.80003	14	0.04733		
19	12	0.0350							4	0.184	4	0.133			14	0.80133	7	0.048433		
20									10	0.185	4	0.133667			3	0.802	4	0.0500667		
21									5	0.1859	4	0.1350			10	0.80267	17	0.052667		
22									4	0.1872	10	0.13533			4	0.81183				
23											5	0.139433			4	0.82333				
24											12	0.1600			12	0.8700				
Average		0.02899		0.00407		0.1948		0.00582		0.1765		0.1305		98.219		0.7897		0.0443		0.00790
Std Dev		0.00097		0.00016		0.0035		0.00020		0.0027		0.0023		0.027		0.0040		0.0012		0.00033
H		0.0013		0.00056		0.0036		0.00064		0.0034		0.0028		0.45		0.0088		0.0016		0.00072
U ₁		0.0016		0.00058		0.0050		0.00067		0.0043		0.0036		0.45		0.0096		0.0020		0.00079
t-statistic		2.10		2.18		2.13		2.11		2.08		2.07		2.13		2.07		2.09		2.23
U ₂		0.0034		0.0013		0.011		0.0014		0.0090		0.0075		0.97		0.020		0.0042		0.0018
U ₃		0.00078		0.00035		0.0027		0.00033		0.0019		0.0015		0.24		0.0041		0.00091		0.00053
Certified		0.029		0.0041		0.195		0.0058		0.177		0.130		98.2		0.79		0.044		0.0079
Uncertainty		0.002		0.0004		0.005		0.0007		0.005		0.004		0.2		0.01		0.002		0.0005
Tolerance		0.006		0.0012		0.015		0.0021		0.015		0.012		1.0		0.03		0.006		0.0018

Analysis	*	Ni	*	O	*	P	*	S	*	Si	*	Sn	*	Ti	*	V	*	W
1	8	0.0957	2	0.00070667	12	0.0094	12	0.0200	5	0.2229	3	0.009	5	0.000233	4	0.0006	4	0.0009667
2	4	0.098667	2	0.0007667	10	0.01	3	0.022	4	0.226	12	0.0091334	12	0.00029	12	0.00065	4	0.0011
3	4	0.10	2	0.00077	5	0.0104	10	0.022	10	0.227	10	0.0093	5	0.00050	14	0.00073	12	0.0012
4	10	0.10	2	0.001	7	0.0108	1	0.023	3	0.23	12	0.0096	5	0.00051334	5	0.00091	5	0.0012667
5	4	0.10133	2	0.001113	10	0.011667	10	0.023	4	0.2300	5	0.009633	4	0.0005667	3	0.001	5	0.0012667
6	4	0.1019	2	0.00143167	4	0.0117	2	0.0231667	4	0.23	4	0.009667	12	0.0005667	3	0.001	12	0.00133
7	4	0.102667	2	0.001433	4	0.0118667	3	0.024	3	0.231	10	0.01	3	0.0006	4	0.0010	5	0.0013667
8	3	0.103	2	0.0015	3	0.012	1	0.0240667	14	0.232	4	0.0101	3	0.0007	10	0.00103	4	0.001533
9	10	0.10333	2	0.001533	4	0.0122	1	0.0243	6	0.233	4	0.010133	4	0.0008	4	0.0011	3	0.0018
10	4	0.10333	2	0.001667	4	0.0123	1	0.02433	4	0.23333	5	0.0101667	10	0.001	5	0.00113	10	0.002
11	3	0.104	2	0.00199	4	0.01233	1	0.025233	4	0.23367	3	0.0102	3	0.001	5	0.00113		
12	3	0.105	2	0.0022	4	0.01233	1	0.0253	4	0.23563	10	0.0102667	4	0.0010667	4	0.00117		
13	4	0.105333	2	0.00221	3	0.0126	1	0.0257667	4	0.23667	4	0.0103	14	0.001233	4	0.00117		
14	10	0.106	12	0.0024	3	0.0126	3	0.0258	10	0.237	5	0.01033	4	0.0020667	12	0.0013		
15	4	0.106767			10	0.0127667	17	0.02633	3	0.237	5	0.0103667	4	0.002433				
16	10	0.107667			4	0.0128	1	0.026533	17	0.24	4	0.0106433						
17	14	0.108333			14	0.012933	1	0.02667	4	0.240	3	0.011						
18	3	0.11			10	0.013	1	0.027	3	0.24								
19	4	0.1107			3	0.013			4	0.24247								
20	4	0.1110667			4	0.0135			4	0.24667								
21	5	0.112833			4	0.013667			10	0.25								
22	17	0.118667							12	0.25333								
23	12	0.1200							10	0.260								
24																		
Average		0.1045		0.001420		0.01202		0.024361		0.2368		0.00992		0.000905		0.00092		0.00115
Std Dev		0.0020		0.000080		0.00041		0.000075		0.0028		0.00036		0.000082		0.00010		0.00013
H		0.0025		0.00039		0.00086		0.0012		0.0040		0.00079		0.00034		0.00034		0.00036
U ₁		0.0032		0.00040		0.00095		0.0012		0.0049		0.00087		0.00035		0.00036		0.00039
t-statistic		2.07		2.16		2.09		2.11		2.07		2.12		2.14		2.16		2.26
U ₂		0.0067		0.00086		0.0020		0.0025		0.010		0.0018		0.00075		0.00077		0.00088
U ₃		0.0014		0.00023		0.00043		0.00059		0.0021		0.00045		0.00019		0.00021		0.00028
Certified		0.104		0.0014		0.012		0.024		0.237		0.0099		0.0009		0.0009		0.0014
Uncertainty		0.005		0.0005		0.001		0.001		0.007		0.004		0.0004		0.0002		0.0005
Tolerance		0.015		0.0010		0.003		0.003		0.021		0.0018		0.0008		0.0006		0.0011

Analysis	*	B	*	Ca	*	Mg	*	Nb	*	Pb	*	Sb	*	Zr
1	5	0.00006	12	0.000031	12	0.000043	12	0.000082	5	0.0001	4	0.0010533	5	0.0000433
2	12	0.000061	12	0.000055	5	0.0000533	12	0.0000967	5	0.0001	10	0.001233	5	0.0000533
3	12	0.0000753	3	0.00023	12	0.00007267	5	0.0001	12	0.00011	4	0.0013667	12	0.000054
4	4	0.0001	4	0.0007	5	0.0002	5	0.0001733	5	0.00012	12	0.0014	12	0.00008967
5	4	0.00013333	5	0.00083333	3	0.00022	4	0.0002	12	0.00017			4	0.0006
6	3	0.00022			4	0.0003633	3	0.0005	14	0.0002			4	0.0013
7	7	0.00041			14	0.0012	10	0.001	3	0.0002			3	0.0014
8	4	0.0008					4	0.0014	4	0.0034			4	0.0033
9							3	0.002					4	0.0039
Average		0.00023		0.00037		0.00031		0.00062		0.00055		0.0013		0.0012
Std Dev		0.00014		0.00048		0.00027		0.00099		0.00084		0.0056		0.0033
H		0.00024		0.00027		0.00026		0.0003		0.00030		0.0004		0.0004
U ₁		0.00028		0.00055		0.00038		0.0010		0.00089		0.0056		0.0034
t-statistic		2.36		2.78		2.45		2.31		2.36		3.18		2.31
U ₂		0.00066		0.0015		0.00092		0.0024		0.0021		0.018		0.0077
U ₃		0.00023		0.00068		0.00035		0.00080		0.00075		0.0089		0.0026
Informational		(0.0002)		(0.0004)		(0.0003)		(0.0006)		(0.0006)		(0.001)		(0.001)

For each element, in accordance with the requirements of ISO Guides 34 and 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.

Analysis	*	Ag	*	Ce	*	Cl	*	Ga	*	Ge	*	K	*	La	*	Na	*	Nd	*	Re
1	12	0.24	12	0.02	12	0.01	12	7.2	12	69	12	0.06	12	0.007	12	0.02	12	0.006	12	0.03
2	12	0.24	12	0.03	12	0.02	12	7.3	12	72			12	0.008	12	0.02	12	0.006	12	0.03
3	12	0.24	12	0.03			12	7.4	12	73			12	0.009	12	0.02	12	0.009	12	0.04
Analysis	*	Ta	*	Zn																
1	1	4.67	12	0.74																
2			12	0.78																
3			12	0.78																
4			3	10																
5			4	24																

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, Guide 34
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Evans Analytical Group	Liverpool, NY	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Exova	Santa Fe Springs, CA	A2LA	17025
Exova	Glendale Heights, IL	A2LA	17025
TUV Rheinland	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: 13X12534, 13X12853, 28X6255; AR 612B, 645, 654, 670, 673, 875, 892, 911A, 950, 1648, 1652, 1653, 8620; BAS 4/88, 55, 206/3, 245, 335, 344, 409, 433, 451, 459, 464/1; BS CCS-2, CSN 2-2, H-13, SS3951, 30D, 48B, 61C, 61G, 62G, 93F, 199B, 200-4, 304, 304A, 316E, 410C, 718C, 718D, 750C, 1026, 1030, 2001, 2931A, 2931B, 2941, 8620E; CZ 2005A; ECRM 85-1, 86-1, 87-1; IARM 28C, 28D, 28E, 28F, 28G, 28H, 28I, 62B, 62E, 241A; IMZ 1.7/4, 73, 74, 111, 112, 184; LECO 501-197, 501-320, 501-501, 501-503, 501-504, 501-505, 501-550, 501-644, 501-646, 501-674, 501-675, 501-676, 501-677, 501-991, 501-993, 502-197, 502-416, 502-868, 502-873, 504-646; SRM 55D, 72F, 90, 101C, 132A, 160B, 361, 362, 363, 364, 365, 1095, 1155A, 1244, 1261A, 1262A, 1264A, 1265A, 1269, 1413, 3107, 3109A, 3137, 3163, 3169; Y 41340b.

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 — AR 8620; BAS 4/88; BS CCS-2, 61C, 2001, 2931A, 2931B, 2941; CZ 2005A; LECO 501-505, 501-676, 501-991, 502-873; SRM 362; Y 41340b.

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 1018 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 Republic Steel; Canton, OH.

Form: This CRM is machined in the form of a disc, approximately 38 mm in diameter and 19 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 1018-112917. 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 9001:2008 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 9001:2008 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 November 29, 2017.

Beau R. Brammer
President