

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 2931B

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	0.0191	0.0006	P	0.0108	0.0004
As	0.0033	0.0003	S	0.0292	0.0007
B	0.0002	0.0001	Sb	0.0012	0.0002
C	0.159	0.002	Si	0.207	0.002
Ca	0.0002	0.0001	Sn	0.0062	0.0003
Co	0.0056	0.0003	Ti	0.0008	0.0002
Cr	0.080	0.001	V	0.0014	0.0002
Cu	0.098	0.001	W	0.0007	0.0002
Mg	0.0001	0.0001	Zr	0.0005	0.0002
Mn	0.788	0.006			
Mo	0.0329	0.0007			
N	0.0076	0.0004			
Nb	0.0011	0.0003			
Ni	0.083	0.001			
O	0.0021	0.0004			

Informational Values^{3,4}

Fe [98.5]* Pb (0.00004) Ta (0.0004)

* By difference

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.

⁴ Values in parentheses are not certified and are provided for information only.

Trace element information value for Ga, is shown on page 4.

The requirements of ISO Guides 31, 34, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis. This is a Certified Reference Material as defined by ISO Guide 30.

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu
1	5	0.0177	10	0.0024	4	0.00015	1	0.156	5	0.00010	5	0.0048	5	0.075	5	0.093
2	5	0.0177	9	0.0029	7	0.00016	1	0.156	4	0.00010	5	0.0049	4	0.078	5	0.094
3	3	0.0178	5	0.0029	4	0.00020	1	0.160	3	0.00022	5	0.0051	5	0.078	3	0.096
4	5	0.0181	5	0.0031	5	0.00020	3	0.160	14	0.00022	5	0.0054	5	0.078	10	0.097
5	4	0.0183	5	0.0036	14	0.00022	1	0.160	4	0.00025	5	0.0055	3	0.079	5	0.097
6	4	0.0183	5	0.0036	3	0.00022	1	0.160	4	0.00025	3	0.0056	4	0.079	4	0.098
7	5	0.0184	14	0.0036	5	0.00030	1	0.160	5	0.00028	4	0.0057	4	0.079	4	0.098
8	5	0.0185	3	0.0037	5	0.00030	1	0.161	3	0.00030	4	0.0057	14	0.080	4	0.098
9	3	0.0192	5	0.0038			1	0.161	4	0.00030	3	0.0058	10	0.080	4	0.098
10	14	0.0200	5	0.0039			1	0.162			10	0.0059	4	0.080	5	0.099
11	4	0.0209					3	0.162			8	0.0064	4	0.081	14	0.099
12	10	0.0210					1	0.162			4	0.0064	10	0.082	3	0.100
13							1	0.163					3	0.084	10	0.100
14							1	0.165							8	0.101
15															4	0.102
Average		0.01906		0.00329		0.000207		0.1590		0.000221		0.00559		0.0797		0.0982
Std dev		0.00058		0.00023		0.000055		0.0017		0.000049		0.00028		0.0014		0.0013
H		0.00070		0.00031		0.00013		0.0024		0.00013		0.00039		0.0016		0.0018
U ₁		0.00091		0.00038		0.00014		0.0029		0.00014		0.00048		0.0021		0.0022
t-statistic		2.20		2.26		2.36		2.16		2.31		2.20		2.18		2.14
U ₂		0.0020		0.00087		0.00032		0.0064		0.00031		0.0011		0.0045		0.0047
U ₃		0.00058		0.00027		0.00011		0.0017		0.00010		0.00031		0.0013		0.0012
Certified		0.0191		0.0033		0.0002		0.159		0.0002		0.0056		0.080		0.098
Uncertainty		0.0006		0.0003		0.0001		0.002		0.0001		0.0003		0.001		0.001
Tolerance		0.0020		0.0009		0.0002		0.006		0.0002		0.0011		0.005		0.005

Analysis	*	Mg	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P
1	5	0.00048	5	0.775	10	0.0300	2	0.0062	10	0.0008	5	0.076	2	0.0010	5	0.0098
2	5	0.000067	3	0.776	4	0.0318	2	0.0066	4	0.0010	5	0.078	2	0.0013	4	0.0100
3	3	0.000070	5	0.777	5	0.0320	2	0.0074	14	0.0010	4	0.080	2	0.0020	3	0.0102
4	5	0.00010	4	0.783	5	0.0321	1	0.0075	3	0.0014	14	0.082	2	0.0023	5	0.0104
5	4	0.00010	14	0.785	3	0.0326	2	0.0078	5	0.0014	10	0.083	2	0.0039	4	0.0106
6	8	0.00010	4	0.787	4	0.0327	2	0.0079	5	0.0014	4	0.083	2	0.0043	10	0.0109
7	4	0.00010	4	0.787	4	0.0327	2	0.0080			4	0.083			3	0.0109
8			10	0.790	5	0.0328	2	0.0080			3	0.084			14	0.0110
9			4	0.792	4	0.0329					3	0.084			4	0.0116
10			10	0.794	10	0.0330					4	0.084			4	0.0116
11			4	0.795	3	0.0336					5	0.085			10	0.0120
12			3	0.798	4	0.0350					4	0.086			5	0.0121
13			5	0.804	14	0.0360					8	0.086				
14											10	0.090				
Average		0.000075		0.7885		0.03292		0.00761		0.00111		0.0831		0.00209		0.01085
Std dev		0.000035		0.0060		0.00079		0.00029		0.00018		0.0014		0.00025		0.00043
H		0.00010		0.0071		0.00090		0.00045		0.00021		0.0016		0.00026		0.00053
U ₁		0.00011		0.0094		0.0012		0.00053		0.00027		0.0021		0.00036		0.00068
t-statistic		2.45		2.18		2.18		2.36		2.57		2.16		2.57		2.20
U ₂		0.00026		0.020		0.0027		0.0013		0.00070		0.0045		0.00092		0.0015
U ₃		0.00010		0.0057		0.00074		0.00045		0.00029		0.0012		0.00038		0.00043
Certified		0.0001		0.788		0.0329		0.0076		0.0011		0.083		0.0021		0.0108
Uncertainty		0.0001		0.006		0.0007		0.0004		0.0003		0.001		0.0004		0.0004
Tolerance		0.0003		0.020		0.0027		0.0013		0.0007		0.005		0.0009		0.0015

BS 2931B

* Code for method

Certified values listed as weight percent

Analysis	*	S	*	Sb	*	Si	*	Sn	*	Ti	*	V	*	W	*	Zr
1	1	0.0250	5	0.0008	4	0.197	5	0.0053	5	0.0005	10	0.0010	5	0.00052	5	0.0002
2	10	0.0275	5	0.0008	6	0.202	5	0.0060	4	0.0005	5	0.0010	5	0.00070	5	0.0002
3	1	0.0280	5	0.0012	4	0.204	14	0.0060	3	0.0006	5	0.0012	5	0.00070	5	0.0005
4	1	0.0282	5	0.0012	4	0.204	5	0.0060	3	0.0006	5	0.0013	5	0.00080	5	0.0005
5	1	0.0295	5	0.0012	3	0.206	10	0.0060	5	0.0006	14	0.0013	5	0.00086	5	0.0007
6	1	0.0295	10	0.0012	4	0.207	5	0.0060	5	0.0011	5	0.0013	5	0.00090	3	0.0008
7	1	0.0296	5	0.0012	3	0.208	5	0.0062	4	0.0011	4	0.0014	14	0.00100		
8	3	0.0296	5	0.0015	14	0.208	5	0.0062	5	0.0012	3	0.0016				
9	5	0.0298	14	0.0015	10	0.209	5	0.0065	5	0.0012	10	0.0019				
10	1	0.0298			10	0.210	5	0.0066	14	0.0014	4	0.0019				
11	1	0.0300			5	0.211	10	0.0070			4	0.0019				
12	1	0.0315			5	0.213	9	0.0070								
13	5	0.0318			5	0.214	3	0.0079								
Average		0.02919		0.00120		0.2072		0.00624		0.00082		0.00142		0.000656		0.00046
Std dev		0.00073		0.00012		0.0027		0.00024		0.00012		0.00013		0.000083		0.00010
H		0.00090		0.00021		0.0028		0.00041		0.00019		0.00022		0.00017		0.00016
U ₁		0.0011		0.00024		0.0039		0.00047		0.00022		0.00026		0.00019		0.00018
t-statistic		2.18		2.31		2.18		2.18		2.26		2.23		2.45		2.57
U ₂		0.0025		0.00056		0.0085		0.0010		0.00050		0.00057		0.00047		0.00048
U ₃		0.00069		0.00019		0.0024		0.00029		0.00016		0.00017		0.00018		0.00019
Certified		0.0292		0.0012		0.207		0.0062		0.0008		0.0014		0.0007		0.0005
Uncertainty		0.0007		0.0002		0.002		0.0003		0.0002		0.0002		0.0002		0.0002
Tolerance		0.0025		0.0006		0.008		0.0010		0.0005		0.0006		0.0005		0.0005

BS 2931B

* Code for method

Informational values listed as weight percent

Analysis	*	Fe	*	Pb	*	Ta	*		*	*	*	*
1	14	98.26	5	0.000010	5	0.000005						
2	5	98.43	5	0.000025	5	0.00005						
3	4	98.45	5	0.000030	5	0.0002						
4	4	98.47	14	0.000040	5	0.0009						
5	4	98.48	5	0.000050	14	0.0010						
6	3	98.48	5	0.000050	5	0.0013						
7	5	98.48	5	0.000050								
8	5	98.55	5	0.000050								
Average		98.45		0.000037		0.00043						
Std dev		0.21		0.000022		0.00011						
H		0.49		0.000089		0.00015						
U ₁		0.53		0.000092		0.00019						
t-statistic		2.36		2.36		2.57						
U ₂		1.26		0.00022		0.00048						
U ₃		0.45		0.000077		0.00020						
(Certified)		(98.5)		(0.00004)		(0.0004)						

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 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 times 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 Tolerance is the half width of the 95 % confidence interval for measurements 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.

For further information regarding the confidence interval for the certified value see ISO Guide 35:2006 section 6.

BS 2931B

* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ga	*	*	*	*	*	*	*	*	*
1		5	7.3								

Analytical Method Codes:

- | | | | | | |
|---|-------------------------|----|-------------------------|----|------------------------|
| 1 | Combustion (ASTM E1019) | 7 | Photometric | 13 | Titrimetric |
| 2 | Fusion (ASTM E 1019) | 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 | | |
| 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

Laboratory

Brammer Standard Company, Inc.
Dirats Laboratories
Instytut Metalurgii Zelaza
LECO Corporation
Laboratory Testing, Inc.
Luvak Inc.
National Analysis Center For Iron And Steel
Northern Analytical Laboratory, Inc.
NSL Analytical
Republic Engineered Products
VHG Labs

Location

Houston, TX
Westfield, MA
Gliwice, Poland
St. Joseph, MI
Hatfield, PA
Boylston, MA
Beijing, China
Londonderry, NH
Cleveland, OH
Buffalo, NY
Manchester, NH

Registrar

A2LA
PRI/Nadcap
PCA
BSI
PRI/Nadcap
PRI/Nadcap
CNAS
PRI/Nadcap
PRI/Nadcap
ABS
A2LA

Accreditation

17025, Guide 34
17025
AB 554
9001
17025
17025
17025
17025
9001
17025, Guide 34

A2LA = American Association for Laboratory Accreditation

ABS = ABS Quality Evaluations

BSI = British Standards Institution

CNAS = China National Accreditation Service

Nadcap = National Aerospace and Defense Contractors Accreditation Program

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 of the certified portion of the lot in accordance with ASTM Standard Practice E 1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025. Methods of analysis used were a those listed on page 4.

Traceability: The following Certified Reference Materials were used to validate the analytical data listed on pages 2-4 — 501-024, 501-501, 501-503, 501-506, 501-644, 501-646, 501-676, 501-677, 501-991, 501-992, 502-193, 502-195, 502-328, 502-348, 502-449, 502-456, 502-809; AR 644, 659, 669, 869, 871, 1653; BAS 149/2, 460/1; BS 15A, 2931a, 2942, CSN 2-2, CSN 2D; ECRM 85-1, 86-1, 87-1; IARM 28B, 28C, 32A, 200A, 200B; IMZ 73, 1.73, 1.8/3, 1.81, 1.84, 112, 130, 135, 139; SRM 13g, 293, 361, 363, 1224, 1227, 1261, 1263a, 1264, 1269, 1763, 1766, 1767, 2166, 3101a, 3102a, 3103a, 3107, 3109a, 3112a, 3113, 3114, 3121, 3126a, 3128, 3131a, 3132, 3134, 3136, 3137, 3139a, 3150, 3155, 3161a, 3162a, 3163, 3165, 3169.

Homogeneity: This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the following Reference Materials — SRM 1224, 1227, 1767; BS CSN 2D, 15A, 2941, 2942.

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 1016 is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Source: The bar stock for this CRM was produced by republic Engineered Products, Buffalo, NY.

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 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 you use for production specimens. Avoid overheating the sample during surface preparation.

Certificate Number: The unique identification number for this certificate of analysis is 2931B-061912. You may obtain information on revisions of certificates from the internet at www.brammerstandard.com.

Safety Notice: A Material Safety Data Sheet (MSDS) 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 Guide 34 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

- E 826 Standard Practice for Testing Homogeneity of a Metal Lot or Batch in Solid Form by Spark Atomic Emission Spectrometry
- E 1019 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
- E 1806 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 30:1992 Terms and definitions used in connection with reference materials + 2008 amendment
- ISO Guide 31:2000 Reference materials - Contents of certificates and labels
- ISO Guide 33:2000 Uses of certified reference materials
- ISO Guide 34:2009 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, 1916 Race Street, Philadelphia, PA, 19103.

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, 2012.

Beau R. Brammer