Brammer Standard Company, Inc.

Certificate of Analysis

BS 718D

Certified Reference Material for 718 Nickel Alloy - UNS Number N07718

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.631**	0.009	**P**	**0.0083**	0.0008
As	**0.0011**	0.0003	**S**	**0.0004**	0.0002
B	**0.0041**	0.0003	**Si**	**0.072**	0.006
C	**0.037**	0.001	**Sn**	**0.0020**	0.0003
Co	**0.368**	0.009	**Ti**	**0.93**	0.01
Cr	**18.32**	0.06	**V**	**0.038**	0.003
Cu	**0.071**	0.001	**W**	**0.049**	0.005
Fe	**18.51**	0.05			
Mg	**0.0038**	0.0004			
Mn	**0.100**	0.006			
Mo	**3.00**	0.01			
N	**0.0084**	0.0006			
Nb	**5.16**	0.06			
Ni	**52.5**	0.2			
O	**0.0015**	0.0002			

Informational Values[3,4]

Ca (0.0006) Pb (0.00006) Sb (0.0002) Ta (0.0022) Zr (0.002)

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

Trace element information values for Bi, Cl, Ga, Ge, K, Na, Re, Se, Te, and Zn are 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.

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BS 718D * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe
1	10	0.597	5	0.000863	4	0.003	1	0.035	12	0.3215	13	18.2225	5	0.063767	3	18.39333
2	5	0.6000	12	0.00090	4	0.003133	3	0.035	3	0.335667	3	18.25667	12	0.0640	3	18.399
3	4	0.621667	15	0.00097	4	0.0034	1	0.03552	4	0.342	10	18.26667	4	0.067867	10	18.4
4	4	0.623067	5	0.001133	5	0.0036	1	0.035833	3	0.354	4	18.27	3	0.069	4	18.44367
5	14	0.625	9	0.001333	12	0.0038	1	0.0359	10	0.356	17	18.27107	4	0.0695	3	18.47
6	3	0.628333	3	0.0014	3	0.004	1	0.036167	8	0.356333	4	18.272	5	0.0700	4	18.475
7	3	0.63	5	0.001833	5	0.00418	1	0.0365	4	0.357333	13	18.28533	3	0.0702	14	18.47667
8	4	0.640	5	0.001933	5	0.004233	3	0.036567	3	0.361	14	18.30	8	0.071167	10	18.485
9	10	0.640	4	0.0022	14	0.004267	1	0.036633	4	0.363	3	18.31	4	0.071467	4	18.48667
10	4	0.640667			3	0.0043	1	0.0368	4	0.3633	10	18.324	5	0.071733	10	18.49
11	4	0.642333			5	0.0043	1	0.036833	14	0.364	4	18.33133	14	0.071867	4	18.51667
12	4	0.644			3	0.0044	1	0.0374	4	0.365	4	18.35667	3	0.0719	4	18.53093
13	4	0.645			7	0.00463	1	0.038	4	0.367133	13	18.36333	4	0.0732733	13	18.54833
14	4	0.648			4	0.0047	1	0.038	4	0.37	3	18.378	10	0.073	4	18.57433
15	4	0.65			3	0.00471	1	0.040007	5	0.374667	4	18.403	4	0.0735	4	18.59667
16					4	0.004967	3	0.0441	4	0.381	4	18.425	4	0.075	4	18.73333
17									4	0.3838	10	18.490	10	0.081633	4	18.79667
18									10	0.384	4	18.5	10	0.082	4	18.817
19									10	0.391667						
20									4	0.415						
Average		0.6307		0.001102		0.00409		0.0375		0.3675		18.315		0.0713		18.508
Std dev		0.0039		0.000073		0.00014		0.0012		0.0040		0.049		0.0017		0.021
H		0.0073		0.00032		0.00050		0.0013		0.0051		0.11		0.0019		0.11
U_1		0.0083		0.00033		0.00052		0.0018		0.0065		0.12		0.0025		0.11
t-statistic		2.14		2.31		2.13		2.13		2.09		2.11		2.11		2.11
U_2		0.018		0.00076		0.0011		0.0038		0.014		0.25		0.0053		0.23
U_3		0.0046		0.00025		0.00028		0.0010		0.0030		0.058		0.0013		0.054
Certified		**0.631**		**0.0011**		**0.0041**		**0.037**		**0.368**		**18.32**		**0.071**		**18.51**
Uncertainty		**0.009**		**0.0003**		**0.0003**		**0.001**		**0.009**		**0.06**		**0.001**		**0.05**
Tolerance		0.027		0.0008		0.0011		0.004		0.027		0.25		0.005		0.23

Analysis	*	Mg	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P
1	4	0.002333	4	0.089933	4	2.948	2	0.0063	4	5.03	4	52.26667	2	0.001133	5	0.006433
2	5	0.002667	8	0.0913	4	2.976667	2	0.007167	3	5.05	4	52.319	2	0.001367	10	0.0073
3	14	0.0032	14	0.091733	3	2.98	2	0.007398	10	5.090	4	52.45	2	0.0014	4	0.007467
4	5	0.0036	12	0.0970	4	2.986667	2	0.0084	4	5.103333	6	52.480	2	0.001433	3	0.007567
5	4	0.003767	4	0.0977	4	2.9875	2	0.00857	4	5.116667	10	52.48	2	0.001493	10	0.0076
6	12	0.0038	3	0.0984	3	2.99	2	0.008733	4	5.118733	7	52.491	2	0.001527	5	0.0078
7	5	0.0040	10	0.099	10	2.99	2	0.008933	3	5.14	3	52.553	2	0.001533	7	0.007967
8	4	0.004057	4	0.1004	14	2.993333	2	0.0090	4	5.154	13	52.57833	2	0.001567	3	0.008
9	5	0.004467	10	0.100667	4	2.996	2	0.009	10	5.156667	16	[52.59]	2	0.001633	14	0.008067
10	3	0.005	4	0.102	4	2.9968	2	0.009133	4	5.163	14	52.63333	2	0.001733	12	0.0081
11			3	0.104	3	2.999	2	0.009333	4	5.166933	16	[52.66987]	2	0.001913	4	0.0082
12			4	0.105	4	2.999467	2	0.009443	4	5.167333	4	52.68667			4	0.008467
13			5	0.106467	4	3.000			14	5.193333	16	[52.75]			3	0.0093
14			4	0.107	10	3.015			10	5.206	10	52.761			7	0.009357
15			5	0.107	10	3.040			4	5.217	4	52.8			4	0.00972
16			3	0.109	4	3.046667			6	5.243333	10	52.82667			4	0.012
17			10	0.109	4	3.052			3	5.279	16	[52.83333]				
18					7	3.174			7	5.286333	3	53.03				
Average		0.00376		0.1001		2.9970		0.00839		5.16		52.501		0.001466		0.00828
Std dev		0.00023		0.0023		0.0061		0.00030		0.12		0.010		0.000074		0.00034
H		0.00049		0.0023		0.023		0.00067		0.04		0.28		0.00035		0.00067
U_1		0.00054		0.0032		0.024		0.00073		0.13		0.28		0.00036		0.00075
t-statistic		2.26		2.12		2.11		2.20		2.11		2.11		2.23		2.13
U_2		0.0012		0.0069		0.050		0.0016		0.27		0.59		0.00080		0.0016
U_3		0.00039		0.0017		0.012		0.00047		0.063		0.14		0.00024		0.00040
Certified		**0.0038**		**0.100**		**3.00**		**0.0084**		**5.16**		**52.5**		**0.0015**		**0.0083**
Uncertainty		**0.0004**		**0.006**		**0.01**		**0.0006**		**0.06**		**0.2**		**0.0002**		**0.0008**
Tolerance		0.0012		0.018		0.05		0.0018		0.27		0.9		0.0008		0.0024

BS 718D * Code for method Certified values listed as weight percent

Analysis	*	S	*	Si	*	Sn	*	Ti	*	V	*	W
1	1	0.0001	12	0.0600	4	0.001667	7	0.892667	4	0.0280	5	0.043067
2	1	0.000267	4	0.0643	5	0.001933	4	0.896667	4	0.0292	4	0.0432
3	1	0.00036	10	0.0652	3	0.002	3	0.898	14	0.031933	5	0.0445
4	1	0.0004	4	0.065233	5	0.0020	10	0.910	14	0.0329	5	0.045133
5	1	0.000453	4	0.0656	5	0.0020	4	0.918667	5	0.034333	4	0.046667
6	1	0.0006	5	0.066267	5	0.0020	10	0.922333	10	0.036	4	0.048
7	1	0.0008	4	0.066333	12	0.0020	4	0.92567	10	0.036467	14	0.049833
8			3	0.0670	5	0.002033	10	0.928	12	0.0370	4	0.050767
9			4	0.068	5	0.002153	3	0.93	5	0.0379	3	0.0529
10			7	0.069567			4	0.931667	3	0.039	4	0.054367
11			14	0.071033			4	0.93625	4	0.039833	4	0.0551
12			4	0.0723			4	0.936667	5	0.0400	4	0.055333
13			10	0.074			4	0.937	5	0.0405	3	0.0572
14			3	0.074			4	0.949	4	0.040533		
15			13	0.079			3	0.95	4	0.0416		
16			3	0.0797			4	0.992067	10	0.044		
17			5	0.088667			4	0.997267	3	0.046667		
18							14	1.006667	4	0.048167		
Average		0.000433		0.0724		0.00197		0.934		0.0376		0.0486
Std dev		0.000055		0.0019		0.00014		0.022		0.0011		0.0014
H		0.00025		0.0019		0.00039		0.010		0.0013		0.0015
U_1		0.00026		0.0027		0.00041		0.024		0.0017		0.0021
t-statistic		2.45		2.12		2.31		2.11		2.11		2.18
U_2		0.00063		0.0058		0.0010		0.051		0.0037		0.0046
U_3		0.00024		0.0014		0.00032		0.012		0.00090		0.0013
Certified		**0.0004**		**0.072**		**0.0020**		**0.93**		**0.038**		**0.049**
Uncertainty		**0.0002**		**0.006**		**0.0003**		**0.01**		**0.003**		**0.005**
Tolerance		0.0004		0.018		0.0010		0.05		0.009		0.015

BS 718D * Code for method Informational values listed as weight percent

Analysis	*	Ca	*	Pb	*	Sb	*	Ta	*	Zr	*	*	*
1	12	0.00012	5	0.000029	12	0.00020	4	0.0016	3	0.0002			
2	4	0.000163	12	0.000030	5	0.0002	12	0.0021	5	0.000283			
3	4	0.0005	9	0.0000867	5	0.00023	5	0.002967	5	0.00035			
4	14	0.0006	5	0.0001			5	0.003667	5	0.000367			
5	3	0.0007							4	0.0004			
6	4	0.000733							4	0.0004			
7	4	0.0012							5	0.00041			
8									4	0.001			
9									4	0.0013			
10									4	0.003933			
11									12	0.0040			
12									3	0.008			
Average		0.00057		0.0000614		0.00021		0.00220		0.0017			
Std dev		0.00098		0.0000082		0.00018		0.00025		0.0054			
H		0.0003		0.00018		0.00022		0.00040		0.0004			
U_1		0.0010		0.00018		0.00028		0.00047		0.0054			
t-statistic		2.45		3.18		4.30		3.18		2.20			
U_2		0.0025		0.00057		0.0012		0.0015		0.012			
U_3		0.00094		0.00028		0.00070		0.00076		0.0034			
(Informational)		**(0.0006)**		**(0.00006)**		**(0.0002)**		**(0.0022)**		**(0.002)**			

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. U_1 is the combined uncertainty from homogeneity and labs. U_2 is U_1 multiplied by the coverage factor (95 % t-statistic). U_3 is U_2 divided by the square root of the number of determinations (n). Thus:

$$C_L = \sqrt{S_L^2 + U_L^2} \qquad W_L = \frac{1}{C_L^2} \qquad A = \frac{\sum_{i=1}^{n} W_L M_L}{\sum_{i=1}^{n} W_L} \qquad S = \frac{1}{\sqrt{\sum_{i=1}^{n} W_L}} \qquad U_1 = \sqrt{H^2 + S^2} \qquad U_2 = t \times U_1 \qquad U_3 = \frac{U_2}{\sqrt{n}}$$

*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 U_3 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.

BS 718D * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Bi	*	Cl	*	Ga	*	Ge	*	K	*	Na	*	Re	*	Se	*	Te	*	Zn
1	12	0.048	12	0.018	12	26	12	4.0	12	0.20	12	0.21	12	1.7	3	10	5	3	12	0.45
2					5	27	5	10					5	2			5	3	5	25
3					5	27	5	10					5	2			5	3	5	25
4					5	28	5	10					5	3					5	28
5					5	31							5	4.3						
6					5	31							5	4.3						
7					5	31							5	4.4						

Analytical Method Codes:

1 Combustion (ASTM E1019)
2 Fusion (ASTM E1019)
3 Spark Atomic Emission
4 ICP Atomic Emission
5 ICP Mass Spectrometry
6 Gravimetric
7 Photometric
8 Flame Atomic Absorption
9 GF Atomic Absorption
10 X-Ray Fluorescence
11 GD Atomic Emission
12 GD Mass Spectrometry
13 Titrimetric
14 DCP Atomic Emission
15 HG Atomic Fluorescence
16 Difference
17 Wet

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

Laboratory	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
LECO Corporation	St. Joseph, MI	A2LA	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
NSL Analytical	Cleveland, OH	ACLASS	17025
Dirats Laboratories	Westfield,MA	ACLASS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Exova	Glendale Heights, Il	A2LA	17025
TUV Rheinland	Electronic City, Bangalore	NABL	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025

A2LA = American Association for Laboratory Accreditation
ACLASS = ANSI-ASQ National Accreditation Board
CNAS = China National Accreditation Service
NABL = National Accreditation Board for Testing and Calibration Laboratories
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 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: 11XC4, 11XC8, 12X357; 501-320, 501-416, 501-501, 501-503, 501-504, 501-550, 501-644, 501-646, 501-674, 501-675, 501-676, 501-992, 501-993, 502-257, 502-348, 502-414, 502-870, 502-873, 502-874, 502-870; AR 511, 645, 657, 659, 670, 875, 892, 1648, 1653, 1656; BAS 4-88, 54, 342, 345, 351, 387, 434; BS H2C, H3C, HON-T, HT6792EV, HT7051EV, 56H, 66L, 75G, 200-2, 510B, 718A, 718B, 725, 2931A; CKD 162A; CT 991, 994; ECRM 85, 86, 87; IARM 54B, 55G, 56A, 56B, 56C, 56D, 56G, 57B, 57C, 57D, 62E, 68C, 100B, 190A; IMZ 63/1, 74, 112, 114, 119, 187, 202; KMS LSCON-001; SRM 15F, 33D, 325, 345, 349, 864, 866, 867, 898, 1208-1, 1208-2, 1243, 1244, 1249, 1264, 1765, 1766, 2166, 2167, 2168, 3109A.

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 — 501-676; BAS 4-88, 351; BS HON-T, HT6308E, 510B, 718A, 718B, 725; CT 991, 994; KMS LCSON-001; SRM 867, 1208-2, 2167, 2168.

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 718D 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 Carpenter Technology Corporation; Reading, PA.

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.

Certificate Number: The unique identification number for this certificate of analysis is 718D-072216. 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. **Phone: (281) 440-9396** **Web: www.brammerstandard.com**
14603 Benfer Road
Houston, Texas 77069-2895 USA **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

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 30:1992 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, 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 July 22, 2016.

Beau R. Brammer