Brammer Standard Company, Inc.

Certificate of Analysis

BS 690B

Certified Reference Material for **Inconel 690** - UNS Number **N06690**

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.166**	0.009	**Ni**	**59.7**	0.1
C	**0.026**	0.001	**O**	**0.0024**	0.0006
Cr	**29.6**	0.1	**S**	**0.0005**	0.0002
Fe	**9.81**	0.09	**Si**	**0.20**	0.01
Mn	**0.103**	0.009	**Ti**	**0.218**	0.007
N	**0.025**	0.001			

Informational Values[3,4]

As (0.0004)	B (0.0004)	Ca (0.0005)	Co (0.003)	Cu (0.007)
Mg (0.0006)	Mo (0.005)	Nb (0.003)	P (0.003)	Sn (0.0006)
V (0.008)	W (0.002)	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 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 Bi, Ga, Ge, Pb, Sb, U, 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.

BS 690B * Code for method Certified values listed as weight percent

Analysis	*	Al	*	C	*	Cr	*	Fe	*	Mn	*	N	*	Ni	*	O	*	S	*	Si
1	4	0.153	3	0.01965	3	29.365	16	9.6301	3	0.07755	2	0.0232	16	[59.17]	2	0.001	12	0.0001167	10	0.18043
2	10	0.1545667	1	0.0232667	13	29.392	3	9.655	4	0.091	2	0.0240	6	59.364667	2	0.0019	1	0.00016	4	0.1920333
3	10	0.1558333	1	0.025	4	29.41	4	9.66	4	0.093	2	0.02417	13	59.381	2	0.0020467	1	0.0001833	4	0.1926667
4	4	0.1573333	3	0.025	4	29.4866667	4	9.76	4	0.0938	2	0.02453	10	59.62	2	0.00205	1	0.0002067	3	0.1942
5	4	0.1594667	1	0.026	4	29.4966667	10	9.78466	4	0.094	2	0.0247	16	[59.6375]	2	0.00206	1	0.00030	5	0.1976667
6	5	0.160	1	0.026	10	29.4966667	4	9.797	4	0.09677	2	0.02503	10	59.654	2	0.0020667	1	0.0003467	4	0.1986667
7	4	0.1606	1	0.026	10	29.529	4	9.811	5	0.09757	2	0.02547	16	[59.65667]	2	0.0021333	4	0.0004	6	0.2006667
8	4	0.1613333	1	0.0263	4	29.550	4	9.82767	4	0.09763	2	0.02547	4	59.74	2	0.0022	3	0.0004067	4	0.2016667
9	3	0.16525	1	0.0264	10	29.58	3	9.9083	10	0.09907	2	0.02563	18	59.756867	2	0.0025067	1	0.0005	3	0.20175
10	4	0.169	1	0.0264667	13	29.5933333	10	9.92	10	0.101	2	0.026	10	59.8527	2	0.0030267	1	0.0006667	4	0.2038
11	4	0.1699333	1	0.0266667	10	29.6030667	4	9.92	4	0.10267	2	0.026	16	[59.933]	2	0.00309	3	0.0008	4	0.205
12	3	0.1708	4	0.027	4	29.6126667	10	9.940	10	0.1052	2	0.02647	16	[59.9433]	2	0.00406	3	0.000875	4	0.2050
13	4	0.1726667	3	0.0275	3	29.6925	10	9.9457	8	0.10733	2	0.02704	4	59.98	2	0.0047333	1	0.001	3	0.20525
14	4	0.1757667	1	0.0276333	4	29.7233333	4	9.98533	4	0.1099							10	0.0011	10	0.2059667
15	3	0.17875	3	0.02845	18	29.8119667	13	9.99033	10	0.112									10	0.208
16	10	0.1820	1	0.0295667	4	29.83	4	9.99567	4	0.11267									6	0.2106667
17	4	0.195	1	0.0301	3	29.9175	4	10.0633	4	0.1225									4	0.2203333
18					4	30.0033333	4	10.1038	3	0.1272									4	0.229
19									3	0.128										
Average		0.1661		0.0256		29.6098		9.8089		0.1029		0.0253		59.730		0.00242		0.000504		0.2022
Std Dev		0.0040		0.0012		0.0093		0.0092		0.0024		0.0010		0.065		0.00018		0.000085		0.0043
H		0.0038		0.0015		0.098		0.045		0.0029		0.0015		0.17		0.00054		0.0003115		0.0041707
U_1		0.0055		0.0019		0.099		0.046		0.0038		0.0018		0.18		0.00057		0.00032		0.0060
t-statistic		2.12		2.12		2.11		2.11		2.10		2.18		2.18		2.18		2.16		2.11
U_2		0.012		0.0040		0.21		0.10		0.0079		0.0039		0.39		0.0012		0.00070		0.013
U_3		0.0028		0.0010		0.049		0.023		0.0018		0.0011		0.11		0.00035		0.00019		0.0030
Certified		**0.166**		**0.026**		**29.6**		**9.81**		**0.103**		**0.025**		**59.7**		**0.0024**		**0.0005**		**0.20**
Uncertainty		0.009		0.001		0.1		0.09		0.009		0.001		0.1		0.0006		0.0002		0.01
Tolerance		0.027		0.004		0.3		0.27		0.027		0.004		0.4		0.0018		0.0005		0.03

Analysis	*	Ti
1	10	0.191
2	4	0.2094667
3	3	0.21
4	4	0.2100667
5	3	0.21125
6	4	0.212
7	4	0.2146667
8	5	0.2146667
9	3	0.21525
10	10	0.218
11	4	0.218
12	4	0.219
13	4	0.2193333
14	4	0.2196667
15	4	0.2202667
16	4	0.2236667
17	10	0.2251667
18	10	0.2335533
19	19	0.255
Average		0.2177
Std Dev		0.0032
H		0.0043416
U_1		0.0054
t-statistic		2.10
U_2		0.011
U_3		0.0026
Certified		**0.218**
Uncertainty		0.007
Tolerance		0.021

BS 690B * Code for method Informational values listed as weight percent

Analysis	*	As	*	B	*	Ca	*	Co	*	Cu	*	Mg	*	Mo	*	Nb	*	P	*	Sn	*	V	*	W	*	Zr
1	5	0.000197	4	0.0001	12	0.0000137	12	0.00036	10	0.001	3	0.00005	4	0.00107	5	0.000107	5	0.000433	3	0.000275	4	0.0061	12	0.0000557	12	0.000039
2	3	0.000275	4	0.0001	17	0.00033333	5	0.00055	10	0.003	17	0.0004	3	0.0023	5	0.0001367	4	0.0012	12	0.0003533	4	0.00633	5	0.00031333	5	0.00005
3	15	0.0002933	12	0.0001233	4	0.00047667	5	0.0014	4	0.0043	4	0.00058	12	0.00357	5	0.0002	4	0.0012333	5	0.0003867	16	0.0065	3	0.001075	5	0.0002133
4	5	0.0003	5	0.000163	3	0.000615	3	0.0018	4	0.0043	5	0.0007	10	0.004	12	0.0009933	5	0.00140	5	0.0004	1	0.00677	3	0.0011	3	0.001825
5	5	0.0004	3	0.0001775	3	0.00062333	5	0.0019	3	0.00435	12	0.00083	5	0.00413	10	0.0014667	12	0.0014	5	0.00042	4	0.0069	4	0.0014	4	0.0023
6	3	0.00045	5	0.0002067	5	0.00064333	4	0.00267	3	0.0050	5	0.00088	5	0.00434	4	0.002	10	0.0021	5	0.0004333	10	0.00707	4	0.0017	10	0.0023
7	12	0.0004933	7	0.0002267			4	0.003	12	0.00577	4	0.0011	4	0.00439	10	0.002	10	0.0026067	5	0.0006	5	0.0072	10	0.00183	3	0.00245
8	5	0.0009	3	0.0006225			10	0.00303	5	0.00613			5	0.0048	4	0.0029667	3	0.002725	4	0.001	3	0.00723	5	0.00286667	4	0.0025667
9			4	0.0018			3	0.00343	5	0.00713			10	0.00607	4	0.0032	5	0.0027333	3	0.0012	2	0.00785	5	0.00746667	10	0.0030767
10							3	0.00363	4	0.00734			4	0.00617	3	0.003875	4	0.0029			10	0.0084				
11							4	0.00377	5	0.00742			4	0.00627	4	0.0041667	4	0.0029667			1	0.01003				
12							4	0.004	8	0.00796			10	0.00633	4	0.0042333	5	0.0032			5	0.01047				
13							10	0.00474	4	0.00803			4	0.009	3	0.004675	3	0.003475			6	0.01107				
14									4	0.00807					3	0.0048	10	0.0035667			3	0.0116				
15									10	0.00896							4	0.005			2	0.0120				
16									4	0.009							3	0.0065								
17									3	0.00998																
18									4	0.01093																
19									10	0.01117																
Average		0.00041		0.00039		0.00045		0.003		0.007		0.0008		0.005		0.0025		0.0027		0.00056		0.008		0.0020		0.0016
Std Dev		0.00047		0.00040		0.00065		0.010		0.032		0.0012		0.025		0.0091		0.0097		0.00083		0.047		0.0079		0.0058
H		0.00029		0.00029		0.00030		0.001		0.001		0.0003		0.001		0.0005		0.0006		0.00032		0.001		0.0005		0.0005
U_1		0.00056		0.00049		0.00072		0.010		0.032		0.0013		0.025		0.0091		0.0097		0.00089		0.047		0.0079		0.0058
t-statistic		2.36		2.31		2.57		2.18		2.10		2.45		2.18		2.16		2.13		2.31		2.14		2.31		2.31
U_2		0.0013		0.0011		0.0018		0.022		0.068		0.0031		0.054		0.020		0.021		0.0021		0.10		0.018		0.013
U_3		0.00047		0.00038		0.00075		0.0062		0.016		0.0012		0.015		0.0052		0.0052		0.00068		0.026		0.0061		0.0045
Informational		(0.0004)		(0.0004)		(0.0005)		(0.003)		(0.007)		(0.0006)		(0.005)		(0.003)		(0.003)		(0.0006)		(0.008)		(0.002)		(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 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 690B * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Bi	*	Ga	*	Ge	*	Pb	*	Sb	*	U	*	Zn
1	12	0.19	12	26	12	2.8	5	1.0	5	0.5	12	0.007	5	28
2	12	0.20	12	26	12	2.8	5	1.3	5	0.5	12	0.008	5	28
3	12	0.20	12	26	12	3.1	12	1.3	12	0.56	12	0.008	5	33
4							12	1.4	12	0.56			12	41
5							12	1.4	5	0.6			12	41
6							5	1.5	12	0.6			12	42

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 AAS
18 Wet
19 PIXE

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
NSL Analytical	Cleveland, OH	ANAB	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Carpenter Technology Corporation	Reading, PA	A2LA	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Exova	Santa Fe Spring, CA	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Exova	Glendale Heights, IL	A2LA	17025
TUV Rheinland Pvt Ltd	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: AR 612B, 654, 670, 875, 882, 892, 1648, 1650, 1652, 1653; BAS 4/94, 387; BS H2C, H2D, H3C, H8, HON-U, 200-1, 200-4, 200A, 351, 600-2, 600-3, 600-5, 600-6, 600C, 690, 690A, 750A, 750C, 750D; ECRM 385; IARM 53C, 53F, 54B, 56C, 56D, 56G, 57B, 57C, 59A, 63E, 68C, 100B, 189A, 190A, 201, 201A, 338A; LECO 501-320, 501-501, 501-504, 501-644, 501-676, 501-993, 502-712, 502-873, 502-921; NCS NS20035b; SRM 166B, 349, 864, 865, 866, 867, 1244, 1249, 2159.

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 — BAS 4/94; BS HON-U, 200-1, 200-4, 200A, 351, 600-2, 600-3, 600-5, 600-6, 600C, 690, 690A, 750A, 750C, 750D; IARM 189A, 338A; LECO 501-676, 502-873; NCS NS20035B; SRM 1244.

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 690B 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 Next Generation Metals; Boca Raton, FL.

Form: This CRM is machined in the form of a disc, approximately 51 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 690B-092118. 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) 440-9396Web: 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 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 9001:2015 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 35:2006 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 September 21, 2018.

Beau R. Brammer

President