Brammer Standard Company, Inc.

Certificate of Analysis

BS 625F

Certified Reference Material for Inconel 625 - UNS Number N06625

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.147**	0.009	**Mn**	**0.094**	0.009
As	**0.0011**	0.0004	**Mo**	**9.11**	0.07
B	**0.0031**	0.0004	**Nb**	**3.53**	0.03
C	**0.0215**	0.0008	**Ni**	**60.72**	0.08
Co	**0.042**	0.003	**P**	**0.0069**	0.0009
Cr	**21.89**	0.09	**Si**	**0.106**	0.009
Cu	**0.150**	0.007	**Sn**	**0.0008**	0.0003
Fe	**3.76**	0.03	**Ti**	**0.27**	0.01
H	**0.0004**	0.0002	**V**	**0.014**	0.001
Mg	**0.0071**	0.0007	**W**	**0.034**	0.003

Reference Values[3,4]

	Reference Value[1]	Estimate of Uncertainty[2]		Reference Value[1]	Estimate of Uncertainty[2]
N	**0.018**	0.002	**Sb**	**<0.001**	
O	**<0.01**		**Ta**	**<0.01**	
Pb	**<0.001**		**Zr**	**<0.02**	
S	**0.0004**	0.0002			

[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] Reference values not certified and are provided for information only.

Trace element information values for Ag, Au, Ca, Ga, Ge, Ir, Os, Pt, Re, Rh, U, and Zn are shown on page 4.

The requirements of ISO Guides 30, 31, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis.

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BS 625F * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	H	*	Mg
1	3	0.13	5	0.000533	12	0.0017333	3	0.0182	12	0.037333	3	21.7	5	0.132	4	3.609	2	0.000214	11	0.0065
2	11	0.132	3	0.0008	4	0.0027667	1	0.019	5	0.038033	17	21.733167	4	0.143	4	3.667667	2	0.000287	4	0.0066
3	3	0.139	9	0.0008	5	0.0029667	1	0.02013333	4	0.039733	11	21.8	4	0.14525	10	3.73	2	0.000329	12	0.0066
4	5	0.139333	4	0.000867	4	0.0029667	1	0.02076667	3	0.041	4	21.87	10	0.148	10	3.74	2	0.00038	4	0.0066
5	4	0.141333	15	0.00136	4	0.0030	1	0.0208	14	0.0419	13	21.879333	8	0.149	4	3.7514	2	0.000387	5	0.006667
6	10	0.146	5	0.00148	4	0.0030667	1	0.0208	4	0.042	10	21.89	14	0.149667	4	3.773333	2	0.000533	4	0.007067
7	4	0.149	5	0.001533	14	0.0030667	1	0.02096667	4	0.042033	14	21.9	3	0.15	4	3.779333	2	0.000547	14	0.007267
8	4	0.1495	12	0.0018	4	0.0031	1	0.0212	4	0.042333	10	21.90	11	0.15	14	3.783333			4	0.007367
9	14	0.15			3	0.0032	1	0.0216	4	0.042833	4	21.9022	4	0.150233	4	3.788667			4	0.0077
10	4	0.150333			7	0.0032567	1	0.0218	11	0.0429	4	21.903333	4	0.150267	11	3.79				
11	4	0.151			3	0.0034	3	0.022	10	0.043	4	21.907067	4	0.151533	3	3.79				
12	4	0.151433			11	0.0036	1	0.022	3	0.0438	4	21.9285	4	0.1564	4	3.793033				
13	4	0.155667			4	0.0053333	1	0.02226667	4	0.0439	4	21.946667	4	0.156667	3	3.8				
14	4	0.158767					1	0.02233333	4	0.0453	3	21.96	4	0.158	4	3.804467				
15	4	0.16825					1	0.02283333			4	21.983667	3	0.16						
16							1	0.023			4	22.0675								
17							11	0.025												
Average		0.1470		0.00115		0.003137		0.021453		0.042		21.891965		0.1503		3.757160		0.000330		0.00715
Std Dev		0.0028		0.00011		0.000098		0.000077		0.0014		0.000079		0.0029		0.000085		0.000014		0.00027
H		0.0039		0.00045		0.00066		0.0015		0.002082		0.070		0.0039		0.023		0.00029		0.00094
U_1		0.0048		0.00046		0.00067		0.0015		0.0025		0.070		0.0048		0.023		0.00029		0.00098
t-statistic		2.14		2.36		2.18		2.12		2.16		2.13		2.14		2.16		2.45		2.31
U_2		0.010		0.0011		0.0015		0.0032		0.0054		0.15		0.010		0.050		0.00070		0.0022
U_3		0.0026		0.00039		0.00041		0.00078		0.0015		0.037		0.0027		0.013		0.00027		0.00075
Certified		**0.147**		**0.0011**		**0.0031**		**0.0215**		**0.042**		**21.89**		**0.150**		**3.76**		**0.0004**		**0.0071**
Uncertainty		0.009		0.0004		0.0004		0.0008		0.003		0.09		0.007		0.03		0.0002		0.0007
Tolerance		0.027		0.0011		0.0015		0.0032		0.009		0.27		0.021		0.09		0.0003		0.0022

Analysis	*	Mn	*	Mo	*	Nb	*	Ni	*	P	*	Si	*	Sn	*	Ti	*	V	*	W
1	4	0.0827	4	8.85925	3	3.46	4	60.5066667	5	0.005797	4	0.0627333	5	0.0006	5	0.242333	5	0.0122	12	0.026333
2	5	0.083267	4	9.04	10	3.50	4	60.5803	11	0.006	14	0.0959667	5	0.000693	4	0.242667	4	0.0123	14	0.031767
3	14	0.085667	3	9.05	4	3.5075	4	60.6733333	6	0.006467	10	0.099	9	0.0007	4	0.24775	11	0.0133	11	0.0319
4	4	0.089867	10	9.07	4	3.5113333	16	[60.68]	10	0.0066	3	0.10	5	0.000743	10	0.248	4	0.013333	4	0.032067
5	4	0.093233	4	9.070967	4	3.512	16	[60.7]	4	0.006767	4	0.1009667	4	0.000833	14	0.257333	4	0.013833	3	0.0323
6	10	0.094	11	9.1	4	3.5192	13	60.7113333	4	0.007	5	0.1023333	4	0.000893	4	0.258733	5	0.0139	4	0.0324
7	3	0.0941	4	9.1162	10	3.54	4	60.7247333	4	0.007067	4	0.1033667	3	0.0009	4	0.2592	14	0.013933	4	0.033627
8	11	0.0948	4	9.116667	11	3.54	10	60.73	4	0.007433	1	0.1056667	12	0.000903	4	0.260667	4	0.013933	4	0.034067
9	4	0.095233	3	9.12	4	3.54	16	[60.76367]	4	0.007867	11	0.106			4	0.2611	10	0.014	10	0.037
10	4	0.0955	4	9.122567	4	3.543	10	60.77	3	0.0083	3	0.107			4	0.262	4	0.014333	5	0.040233
11	4	0.095733	14	9.126667	14	3.5433333	16	[60.7791233]			6	0.1087333			4	0.2639	3	0.0152	4	0.040333
12	4	0.096167	4	9.13	3	3.55	16	[60.88]			4	0.1120667			10	0.266	4	0.016167	4	0.057067
13	10	0.099	4	9.132667	4	3.5535	14	60.8963333			4	0.114			11	0.268	12	0.0170		
14	3	0.10	4	9.161833	4	3.57					4	0.1226667			3	0.269				
15	4	0.103333	10	9.18	4	3.625					4	0.1433333			3	0.27				
16			4	9.3059											4	0.288				
Average		0.0937		9.106420		3.534324		60.722730		0.00693		0.105589		0.00078		0.2639		0.01406		0.0340
Std Dev		0.0021		0.000079		0.000082		0.000088		0.00010		0.000082		0.00011		0.0035		0.00050		0.0013
H		0.0031		0.040		0.023		0.14		0.00092		0.0033		0.00039		0.0052		0.0013		0.0019
U_1		0.0037		0.040		0.023		0.14		0.00093		0.0033		0.00040		0.0063		0.0014		0.0023
t-statistic		2.14		2.13		2.14		2.18		2.26		2.14		2.36		2.13		2.18		2.20
U_2		0.0080		0.086		0.048		0.30		0.0021		0.0070		0.0010		0.013		0.0030		0.0050
U_3		0.0021		0.021		0.012		0.083		0.00066		0.0018		0.00034		0.0034		0.00082		0.0015
Certified		**0.094**		**9.11**		**3.53**		**60.72**		**0.0069**		**0.106**		**0.0008**		**0.27**		**0.014**		**0.034**
Uncertainty		0.009		0.07		0.03		0.08		0.0009		0.009		0.0003		0.01		0.001		0.003
Tolerance		0.027		0.21		0.09		0.30		0.0027		0.027		0.0007		0.03		0.003		0.009

BS 625F * Code for method Reference values listed as weight percent

Analysis	*	N	*	O	*	Pb	*	S	*	Sb	*	Ta	*	Zr
1	2	0.0163	2	0.000577	12	0.000014	12	0.000099	4	0.00028	5	0.0018667	11	0.0015
2	2	0.0165	2	0.000633	11	0.000098	1	0.0001	3	0.0003	3	0.0026	4	0.001633
3	2	0.0165	2	0.000733	5	0.00012	1	0.000115	5	0.000367	14	0.0045667	4	0.002233
4	2	0.016767	2	0.00075	4	0.00018	11	0.0002	9	0.0004	4	0.0049667	5	0.009667
5	2	0.016967	2	0.000867	3	0.0002	1	0.00030333	5	0.00065	4	0.0063333	12	0.0098
6	2	0.017333	2	0.001033	9	0.0002	1	0.00031333	5	0.000713	4	0.0065333	4	0.010167
7	2	0.017667	2	0.00113			1	0.00036667	12	0.00077			5	0.010533
8	2	0.0181	2	0.001148			1	0.00043333					5	0.011067
9	2	0.018133	2	0.00139			1	0.00056667					14	0.011667
10	2	0.018633	2	0.0026			6	0.00060377					4	0.014
11	2	0.018733	2	0.007333			1	0.0007						
12	2	0.01905					3	0.0007						
13							1	0.00073333						
Average		0.017557		0.0017		0.000135		0.000403		0.000290		0.00632		0.00678
Std Dev		0.000091		0.0053		0.000047		0.000088		0.000018		0.00024		0.00035
H		0.0014		0.0005		0.00021		0.00031		0.00027		0.00089		0.0019
U_1		0.0014		0.0053		0.00022		0.00032		0.00027		0.00092		0.0019
t-statistic		2.20		2.23		2.57		2.18		2.45		2.57		2.262157
U_2		0.0031		0.012		0.00056		0.00070		0.00067		0.0024		0.0043
U_3		0.00088		0.0036		0.00023		0.00019		0.00025		0.0010		0.0014
Reference		**0.018**		**<0.01**		**<0.001**		**0.0004**		**<0.001**		**<0.01**		**<0.02**
Uncertainty		0.002						0.0002						
Tolerance		0.006						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 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 625F * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ag	*	Au	*	Ca	*	Ga	*	Ge	*	Ir	*	Os	*	Pt	*	Re	*	Rh
1	12	0.96	12	0.13	12	0.54	12	29	12	0.51	12	0.05	12	0.06	12	0.24	12	6.2	12	0.11
2	12	0.96	12	0.14	12	0.60	12	30	12	0.52	12	0.05	12	0.06	12	0.24	12	6.3	12	0.13
3	12	1.00	12	0.14	12	0.62	12	31	12	0.53	12	0.06	12	0.07	12	0.26	12	6.6	12	0.13
4					11	3.0														
5					4	3.0														
6					4	3.0														
7					4	4.0														
8					4	5.0														
9					4	8.0														
10					4	8.0														

Analysis	*	U	*	Zn
1	12	0.02	12	1.3
2	12	0.02	12	1.3
3	12	0.02	12	1.4

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

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
NSL Analytical	Cleveland, OH	ANAB	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Vitkovice Testing Center	Ostrava, Czech Republic	Czech Accreditation Instute	17025
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Luvak Inc.	Boylston, MA	PRI	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Shiva Analyticals (India) Private Limited	Karnataka, 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: 12X31400A, 22X754D, 28C6255M; 501-321, 501-644, 501-676, 502-348, 502-414, 502-704, 502-712, 502-855, 502-863, 502-893, 502-916, 502-928, 502-935, 502-946, 502-963, 502-977; AR 513, 644, 654, 657, 659, 662, 668, 675, 676, 868, 870, 882, 892, 1650, 1652, 1653; BAS 334, 387, 434, 481; BS H230, H-6, H-6B, 160A, 149B, 179C, 183C, 187C, 273, 625, 625A, 625B, 625C, 625D, 625E, 725, 750A, 1016, 1045, 1762, 4340, 4340A; CKD 186A; CSZU CA013; ECRM 85-1, 86-1, 87-1, 377-2; IARM 25B, 54A, 54B, 54E, 54G, 56A, 56C, 62E, 68A, 189A, 190A; IMZ 52/1, 112, 162, 187, 206; JK 21; JSS GS-1d; NCS NS11043, NS11078; SRM 16F, 349, 864, 865, 866, 1245, 1261, 2166.

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: 28X6255M; BS H-6, H-6B, 625, 625A, 625B, 625C, 625E, 725; DSZU CA013; IARM 189A; NCS NS11043, NS11078; SRM 864, 866, 1245.

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 625F 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 Electralloy; Oil City, PA.

Form: This CRM is machined in the form of a disc, approximately 38mm 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 625F-081121. 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 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 August 10, 2011.

Beau R. Brammer

President