

Brammer Standard Company, Inc.

Certificate of Analysis

BS 825F

Certified Reference Material for Incoloy 825 - UNS Number N08825

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.081	0.009		Mo	0.05
B	0.0023	0.0003		N	0.0007
C	0.012	0.001		Ni	0.4
Co	0.064	0.006		O	0.0003
Cr	23.2	0.3		P	0.004
Cu	1.78	0.03		Si	0.03
Fe	30.7	0.3		Ti	0.03
Mg	0.0013	0.0004		V	0.005
Mn	0.521	0.009		W	0.007

Informational Values^{3,4}

As (0.004)	Ca (0.001)	Nb (0.02)	Pb (0.0008)	S (0.005)
Sn (0.0036)	Zr (0.002)			

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, Au, Bi, Cd, Ga, Ge, In, Ir, Na, Os, Pd, Pt, Re, Rh, Ru, Sb, Sr, U, Y, 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	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mg	*	Mn	*	Mo	
1	12	0.0530	14	0.0017	1	0.00970	4	0.0489333	4	22.7067	3	1.709	3	30.18	5	0.0004667	3	0.487	4	3.07	
2	12	0.0623333	12	0.0017	1	0.0101	3	0.054	17	22.7888	3	1.72	3	30.21	12	0.00077	4	0.49947	4	3.08333	
3	10	0.0657333	4	0.00206667	1	0.0104667	4	0.0585	3	22.8	10	1.73	18	30.276667	12	0.0007933	10	0.502	4	3.12333	
4	3	0.0691	3	0.00215	1	0.011	4	0.0589	4	22.8867	4	1.734967	4	30.33	4	0.001	14	0.50267	4	3.12667	
5	4	0.0694333	3	0.0023	1	0.0112667	10	0.059	4	22.94	3	1.74	14	30.466667	10	0.001	3	0.511	10	3.14	
6	5	0.0723333	3	0.0023	1	0.0113	4	0.0590667	3	23	10	1.761	3	30.672	4	0.0010567	4	0.51283	4	3.14567	
7	3	0.0734333	3	0.0025	1	0.0116	8	0.0594	10	23.16	14	1.766667	4	30.73333	3	0.00131	3	0.518	4	3.1463	
8	4	0.075	4	0.00256667	1	0.0116333	12	0.0610	13	23.234	4	1.766667	4	30.785333	4	0.0015	4	0.51967	10	3.14667	
9	4	0.0766333	5	0.00256667	1	0.0120	3	0.0614333	10	23.27	4	1.769833	13	30.806333	5	0.0015	4	0.52	3	3.154	
10	3	0.077	4	0.0026	3	0.0122	14	0.0628	3	23.3	3	1.77	4	30.834167	3	0.00178	4	0.52	4	3.15867	
11	18	0.0776667	7	0.00278	1	0.0123333	4	0.0648667	4	23.3267	4	1.777333	10	30.84	14	0.0019667	4	0.52243	4	3.16333	
12	4	0.0788667	4	0.00293333	1	0.0127333	5	0.0653333	4	23.33	4	1.78	3	30.9	4	0.0022667	10	0.52667	4	3.191	
13	3	0.081	4	0.00366667	3	0.0131	3	0.0668	3	23.383	4	1.783333	10	30.907			3	0.527	3	3.21	
14	4	0.0816667	12	0.00373333	3	0.015	4	0.0689667	4	23.4	4	1.79	4	30.913333			4	0.529	10	3.229	
15	4	0.087			4	0.015	4	0.07	4	23.4	4	1.791667		30.94			8	0.52967	4	3.24777	
16	4	0.088			3	0.015	4	0.071	4	23.5	10	1.8	10	31.10			10	0.53	14	3.28667	
17	14	0.0917667			1	0.016	10	0.078	4	23.5633	4	1.8042	4	31.1			4	0.531	3	3.3	
18	10	0.093							18	23.68	18	1.813333	4	31.17			3	0.54	4	3.30067	
19	4	0.10							10	23.73	8	1.815333					4	0.540	4	3.33053	
20									4	23.7903	4	1.82					4	0.544	18	3.35667	
21											4	1.82									
22											4	1.843667					18	0.55333			
23											3	1.846667									
Average		0.0813		0.002346		0.01188		0.0640		23.157		1.7759		30.73		0.001284		0.521		3.191	
Std Dev		0.0020		0.000076		0.00044		0.0016		0.050		0.0064		0.18		0.000091		0.011		0.071	
H		0.0022		0.00046		0.00085		0.0019		0.12		0.015		0.15		0.00038		0.007		0.024	
U ₁		0.0030		0.00046		0.00096		0.0025		0.13		0.017		0.24		0.00039		0.013		0.075	
t-statistic		2.10		2.16		2.12		2.12		2.09		2.07		2.11		2.20		2.09		2.09	
U ₂		0.0063		0.0010		0.0020		0.0053		0.27		0.035		0.50		0.00085		0.027		0.16	
U ₃		0.0014		0.00027		0.00049		0.0013		0.061		0.0072		0.12		0.00025		0.0060		0.035	
Certified		0.081		0.0023		0.012		0.064		23.2		1.78		30.7		0.0013		0.521		3.19	
Uncertainty		0.009		0.0003		0.001		0.006		0.3		0.03		0.3		0.0004		0.009		0.05	
Tolerance		0.027		0.0010		0.003		0.018		0.9		0.09		0.9		0.0012		0.028		0.16	

Analysis	*	N	*	Ni	*	O	*	P	*	Si	*	Ti	*	V	*	W
1	2	0.0067	16	[38.29667]	2	0.0004233	4	0.0106667	12	0.5	4	0.87	3	0.071	12	0.0077
2	2	0.007	13	38.4413333	2	0.0005	14	0.0124	10	0.53	4	0.873333	4	0.075	4	0.0092
3	2	0.00791	3	38.4566667	2	0.000600	12	0.0130	3	0.532	3	0.888	12	0.081	5	0.0095
4	2	0.0079667	4	38.5	2	0.00071	4	0.013	3	0.537	10	0.888333	5	0.083	12	0.0098333
5	2	0.0081	4	38.5	2	0.0009333	3	0.0149	4	0.56367	4	0.893333	4	0.0838667	4	0.0103
6	2	0.0084	6	38.5023333	2	0.001	3	0.0155667	3	0.591	3	0.896	4	0.0859	5	0.0111667
7	2	0.0085667	4	38.5333333	2	0.0010333	5	0.016	14	0.59867	7	0.898	4	0.0862667	4	0.016
8	2	0.0087733	18	38.5433333	2	0.0010667	3	0.0178	3	0.61267	10	0.901	3	0.0884	10	0.017
9	2	0.0091067	10	38.63	2	0.0014667	3	0.018	4	0.61767	4	0.902667	4	0.0896667	4	0.0221667
10	2	0.00918	10	38.713			10	0.0180	6	0.62133	10	0.91	18	0.0896667	10	0.025
11	2	0.0092	3	38.809	4	0.0180667	4	0.622	3	0.91	4	0.900333	14	0.0297		
12	2	0.0095333	4	38.8531333	4	0.0190333	4	0.62953	4	0.911	14	0.904				
13	2	0.0102	16	[38.9]	4	0.0196667	4	0.63327	3	0.914	3	0.908				
14			3	39.06	10	0.0201	10	0.63867	4	0.917667	4	0.909667				
15			4	39.1	4	0.0206333	4	0.669	4	0.917667	7	0.9091033				
16			4	39.2333333	4	0.0213333	18	0.68	4	0.9297	10	0.092				
17			14	39.4333333	7	0.0213667			3	0.936333	3	0.093				
18			4	39.55	10	0.025			4	0.957333	3	0.0959667				
19					4	0.0256667			4	0.960733						
20					12	0.0266667			14	0.963333						
21									4	0.966067						
Average		0.008511		38.871		0.00086		0.01787		0.6038		0.913		0.0859		0.01455
Std Dev		0.000088		0.063		0.00011		0.00059		0.0047		0.020		0.0020		0.00079
H		0.00074		0.19		0.00033		0.0010		0.00733		0.009684		0.0023		0.0009
U ₁		0.00075		0.20		0.00035		0.0012		0.0087		0.022		0.0030		0.0012
t-statistic		2.18		2.11		2.31		2.09		2.13		2.09		2.11		2.23
U ₂		0.0016		0.42		0.00081		0.0025		0.019		0.046		0.0064		0.0027
U ₃		0.00045		0.10		0.00027		0.00055		0.0046		0.010		0.0015		0.00082
Certified		0.0085		38.9		0.0009		0.018		0.59		0.91		0.086		0.015
Uncertainty		0.0007		0.4		0.0003		0.004		0.03		0.03		0.005		0.007
Tolerance		0.0021		1.2		0.0008		0.012		0.09		0.09		0.015		0.011

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* Code for method

Informational values listed as weight percent

Analysis	*	As	*	Ca	*	Nb	*	Pb	*	S	*	Sn	*	Zr
1	4	0.002	12	0.000005	5	0.0071667	12	0.000061	1	0.0001	12	0.001567	5	0.00005
2	12	0.0039	4	0.00020667	10	0.0073	12	0.000065	1	0.0001	5	0.002667	5	0.000063
3	10	0.005	3	0.00037	12	0.0075	4	0.001	1	0.00016	12	0.0027	12	0.00023
4			5	0.0011	5	0.0080333	3	0.002	12	0.00016	5	0.003033	3	0.0019
5			4	0.00133333	5	0.00886			1	0.0002	3	0.0031	10	0.0022
6			4	0.0055	10	0.0094667			1	0.0003	5	0.00338	4	0.003
7					4	0.011			1	0.0003	4	0.004033	12	0.0088
8					4	0.0122			12	0.00037	3	0.0041		
9					4	0.0149667			1	0.0005	9	0.004367		
10					4	0.0158			1	0.00067	4	0.004433		
11					4	0.0203333			3	0.0009	3	0.006		
12					14	0.0215			3	0.001				
13					3	0.02191			4	0.001				
14					3	0.0229			1	0.0011				
15					3	0.029			3	0.0013				
16					10	0.029			10	0.076				
Average		0.004		0.0014		0.015		0.0008		0.005		0.003580		0.002
Std Dev		0.035		0.0055		0.091		0.0023		0.025		0.000095		0.011
H		0.001		0.0004		0.001		0.0003		0.001		0.00053		0.000
U ₁		0.035		0.0056		0.091		0.0024		0.025		0.00054		0.012
t-statistic		4.30		2.57		2.13		3.18		2.13		2.23		2.45
U ₂		0.15		0.014		0.19		0.0075		0.054		0.0012		0.028
U ₃		0.086		0.0058		0.049		0.0037		0.013		0.00036		0.011
Informational		(0.004)		(0.001)		(0.02)		(0.0008)		(0.005)		(0.0036)		(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. 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.

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* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ag	*	Au	*	Bi	*	Cd	*	Ga	*	Ge	*	In	*	Ir	*	Na	*	Os
1	12	1.1	12	0.23	12	0.02	12	0.16	12	4.9	12	3.7	12	25	12	0.07	12	0.01	12	0.06
2			12	0.35			12	0.17	12	5.1	12	100	12	31	12	0.09	12	0.04		
3			12	0.37			12	0.17	12	5.3	12	100	12	32	12	0.1				
4			12	0.4					12	24	12	110			12	0.11				
Analysis	*	Pd	*	Pt	*	Re	*	Rh	*	Ru	*	Sb	*	Sr	*	U	*	Y	*	Zn
1	12	0.96	12	0.09	12	0.88	12	0.15	12	0.09	12	9.2	12	1.2	12	0.01	12	0.1	12	2.0
2	12	1	12	0.16	12	1	12	0.19									12	1.8	12	23
3	12	1.1	12	0.18	12	1.1	12	0.25									12	2.1	12	25
4			12	0.34	12	1.2											12	2.2	12	25

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 Wet
6 Gravimetric	12 GD Mass Spectrometry	18 PIXE

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
LECO Corporation	St. Joseph, MI	A2LA	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
TUV Rheinland India Pvt Ltd	Bangalore, India	NABL	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Exova	Glendale Heights, IL	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	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: 12X10180, 12X15253, 12X357, 12X41450, 12XLA2, 12XLA3, 13X12859, 13X14211, 13X18004, 13X31254, 13X41001, 13X43100, 13XNSC3, 14XMN2, 14XMN4, 219X0882, 219X8825; AR 654, 657, 659, 670, 676, 871, 875, 891, 1648, 1652, 1653; BAS 4-88, 320, 351, 387, 408, 434, 451; BS H230, H3B, H3C, 189A, 690A, 718D, 725, 800, 825, 825A, 825B, 825C, 825D, 925; CKD 169A, 180A; DSZU CA01A; ECRM 86, 87; IARM 2C, 4C, 16C, 21C, 56C, 56G, 59A, 59B, 59C, 59D, 59E, 154B, 625E; IMZ 1-N4, 112; JK 8F, 21; LECO 501-320, 501-501, 501-502, 501-504, 501-644, 501-674, 501-676, 501-993, 502-411, 502-704, 502-855, 502-870, 502-873, 502-895; SRM 55D, 339, 349, 865, 866, 867, 882, 1245A, 1247, 2159, 3109A, 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 — BAS 4-88, 351; BS H3B, 189A, 690A, 725, 800, 825, 825A, 825B, 825C, 825D, 925; DSZU CA01A; LECO 501-676, 502-873; SRM 867, 882, 1247; 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 825E 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 Acciaierie Valburna S.P.A.; Vicenza, Italy.

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 825F-072717. 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 July 27, 2017.

Beau R. Brammer
President