Brammer Standard Company, Inc.

Certificate of Analysis

BS 400D

Certified Reference Material for Nickel Alloy Monel 400 - UNS Number N04400

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.0231**	0.0008	**Mn**	**0.993**	0.007
B	**0.0009**	0.0002	**Mo**	**0.0024**	0.0003
C	**0.130**	0.002	**Ni**	**63.4**	0.3
Co	**0.032**	0.001	**O**	**0.0008**	0.0002
Cr	**0.0057**	0.0005	**Pb**	**0.0004**	0.0002
Cu	**33.0**	0.1	**S**	**0.0006**	0.0002
Fe	**2.00**	0.01	**Si**	**0.146**	0.002
Mg	**0.0217**	0.0006	**Ti**	**0.064**	0.001

Reference Values[3,4]

	Reference Value	Estimate of Uncertainty		Reference Value	Estimate of Uncertainty
N	**0.00017**	0.00009	**W**	**0.0004**	0.0002
Sn	**0.00012**	0.00009	**Zr**	**0.0003**	0.0002

Informational Values[3,5]

As (0.0001) Ca (0.001) Nb (0.0001) P (0.0010) Sb (0.0001)
Ta (0.009) V (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.

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

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

Trace element information values for Ag, Bi, Cl, Ga, K, Na, Nd, 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 400D * Code for method Certified values listed as weight percent

Analysis	*	Al	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mg
1	12	0.0200	4	0.0006	1	0.122333	3	0.0285	12	0.0042	3	32.61	3	1.923333	3	0.019267
2	3	0.0209	4	0.000867	1	0.127	4	0.031667	3	0.004933	4	32.68	4	1.968667	3	0.02023
3	4	0.021	5	0.000887	3	0.127	3	0.0322	5	0.005767	13	32.938	4	1.974667	4	0.020567
4	10	0.021333	12	0.0010	1	0.127875	4	0.0324	4	0.00585	10	33.03333	4	1.989188	4	0.0211
5	4	0.0223	3	0.00105	1	0.128125	10	0.0325	5	0.005967	4	33.0903	4	1.99	4	0.021433
6	3	0.023	4	0.001067	1	0.129	4	0.032667	5	0.0061	4	33.12333	3	1.99	12	0.0215
7	4	0.023663	3	0.00107	1	0.1297	4	0.033363	4	0.006673	10	33.12775	10	2.002	4	0.02165
8	4	0.0239	5	0.0012	1	0.129753	10	0.033667			6	33.12833	10	2.016333	5	0.0227
9	4	0.0269			1	0.13	4	0.0356			16	33.15333	4	2.0222	4	0.022833
10	10	0.027			1	0.130667					10	33.162	4	2.023333	3	0.024267
11	4	0.027567			1	0.1311					4	33.175	4	2.026667	5	0.0247
12					1	0.131667							10	2.066667	4	0.024933
13					1	0.137633										
Average		0.02306		0.00093		0.1299		0.03237		0.00565		33.035		2.0033		0.02169
Std dev		0.00074		0.00012		0.0012		0.00091		0.00034		0.067		0.0099		0.00059
H		0.0008		0.00024		0.0022		0.0010		0.00044		0.20		0.016		0.00081
U_1		0.0011		0.00027		0.0025		0.0013		0.00056		0.21		0.019		0.0010
t-statistic		2.23		2.36		2.18		2.31		2.45		2.23		2.20		2.20
U_2		0.0025		0.00063		0.0055		0.0031		0.0014		0.48		0.041		0.0022
U_3		0.00075		0.00022		0.0015		0.0010		0.00051		0.14		0.012		0.00064
Certified		**0.0231**		**0.0009**		**0.130**		**0.032**		**0.0057**		**33.0**		**2.00**		**0.0217**
Uncertainty		**0.0008**		**0.0002**		**0.002**		**0.001**		**0.0005**		**0.1**		**0.01**		**0.0006**
Tolerance		0.0025		0.0006		0.006		0.003		0.0014		0.5		0.04		0.0022

Analysis	*	Mn	*	Mo	*	Ni	*	O	*	Pb	*	S	*	Si	*	Ti
1	4	0.980713	3	0.0018	4	63.16667	2	0.0006	5	0.00036	1	0.000137	4	0.13	4	0.062
2	4	0.982333	10	0.002	13	63.24167	2	0.000633	5	0.000407	12	0.00035	10	0.139333	4	0.062233
3	4	0.987667	5	0.002333	10	63.24775	2	0.00072	5	0.0004073	1	0.0004	4	0.1397	3	0.062867
4	4	0.989667	5	0.0024	10	63.38233	2	0.0008	5	0.000423	1	0.00048	10	0.142	4	0.063667
5	4	0.99	3	0.0024	10	63.43333	2	0.00084	5	0.000433	1	0.0005	4	0.144838	3	0.0643
6	3	0.99	4	0.002438	4	63.43667	2	0.000973	12	0.00047	1	0.0007	3	0.15	12	0.065
7	10	0.993333	3	0.0025	4	63.44643	2	0.0010	3	0.0009	1	0.001067	4	0.150333	10	0.06625
8	4	0.9952	4	0.002603	4	[63.44667]	2	0.001007			1	0.001167	5	0.154667	4	0.067488
9	3	1.00	4	0.002633	6	63.76333	2	0.001067					5	0.1600	10	0.068
10	10	1.005	5	0.0028									4	0.160667	4	0.068633
11	10	1.009667													5	0.069333
12															10	0.07
Average		0.9931		0.00240		63.42		0.00084		0.000437		0.000640		0.1462		0.0644
Std dev		0.0057		0.00021		0.14		0.00011		0.000069		0.000078		0.0022		0.0013
H		0.009		0.00032		0.40		0.00023		0.00020		0.00022		0.0024		0.0015
U_1		0.011		0.00038		0.42		0.00026		0.00021		0.00023		0.0032		0.0020
t-statistic		2.23		2.26		2.31		2.31		2.45		2.36		2.26		2.20
U_2		0.024		0.00086		0.97		0.00059		0.00051		0.00054		0.0073		0.0043
U_3		0.0072		0.00027		0.32		0.00020		0.00019		0.00019		0.0023		0.0012
Certified		**0.993**		**0.0024**		**63.4**		**0.0008**		**0.0004**		**0.0006**		**0.146**		**0.064**
Uncertainty		**0.007**		**0.0003**		**0.3**		**0.0002**		**0.0002**		**0.0002**		**0.002**		**0.001**
Tolerance		0.024		0.0009		1.0		0.0006		0.0005		0.0005		0.007		0.004

BS 400D * Code for method Reference values listed as weight percent

Analysis	*	N	*	Sn	*	W	*	Zr
1	2	0.0001	5	0.0000319	12	0.000049		0.0000593
2	2	0.000103	3	0.0001	5	0.0000953		0.0001
3	2	0.00011	3	0.0001	5	0.0001		0.0001
4	2	0.0002	5	0.000133	4	0.0001		0.000267
5	2	0.000253	5	0.000133	10	0.0009		0.0003
6	2	0.000387	12	0.00015	4	0.004567		0.000575
7	2	0.0005	5	0.00016				0.0006
8			5	0.0002				0.001
Average		0.000240		0.000125		0.00037		0.000258
Std dev		0.000058		0.000034		0.00012		0.000058
H		0.00017		0.00016		0.00019		0.000177
U_1		0.00018		0.00016		0.00022		0.00019
t-statistic		2.45		2.36		2.57		2.36
U_2		0.00045		0.00038		0.00057		0.00044
U_3		0.00017		0.00013		0.00023		0.00016
Reference		**0.00017**		**0.00012**		**0.0004**		**0.0003**
Uncertainty		**0.00009**		**0.00009**		**0.0002**		**0.0002**
Tolerance		0.00009		0.00009		0.0004		0.0003

BS 400D * Code for method Informational values listed as weight percent

Analysis	*	As	*	Ca	*	Nb	*	P	*	Sb	*	Ta	*	V
1	12	0.000075	12	0.0014	12	0.00005	12	0.00032	5	0.0000633	10	0.008	5	0.000133
2	5	0.000163			10	0.0002	4	0.000438	5	0.0000892	3	0.0096	5	0.000133
3					3	0.0007	3	0.0009	5	0.0001			12	0.0002
4							4	0.000933	5	0.0001			10	0.0004
5							3	0.001525	5	0.00010				
6							3	0.0021	12	0.00010				
7							10	0.002833						
Average		0.000119		0.00140		0.000136		0.00101		0.000092		0.00883		0.000210
Std dev		0.000052		0.00038		0.000098		0.00014		0.000031		0.00089		0.000062
H		0.00016		0.00027		0.00016		0.00024		0.00015		0.0005		0.000171
U_1		0.00017		0.00046		0.00019		0.00028		0.00015		0.0010		0.00018
t-statistic		12.71		12.71		4.30		2.45		2.57		12.71		3.18
U_2		0.0021		0.0059		0.00081		0.00069		0.00040		0.013		0.00058
U_3		0.0015		0.0059		0.00046		0.00026		0.00016		0.0093		0.00029
(Informational)		**(0.0001)**		**(0.001)**		**(0.0001)**		**(0.0010)**		**(0.0001)**		**(0.009)**		**(0.0002)**

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 times 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 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 400D * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ag	*	Bi	*	Cl	*	Ga	*	K	*	Na	*	Nd	*	Zn
1	5	4.433	5	0.077	12	0.052	12	0.57	12	0.19	12	0.12	12	0.30	12	5.8
2	5	5.024	12	0.14			5	0.62							5	7.7667
3	12	5.8													8	10

Analytical Method Codes:

1 Combustion (ASTM E1019)
2 Fusion (ASTM E 1019)
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 Electrodisposition

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

Laboratory	Location	Registrar	Accreditation
ATI Allvac	Monroe, NC	ACLASS	17025
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
LECO Corporation	St. Joseph, MI	A2LA	17025
NSL Analytical	Cleveland, OH	ACLASS	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Dirats Laboratories	Westfield,MA	ACLASS	17025
ATI Allvac	Lockport, NY	ACLASS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Exova	Glendale Heights, Il	A2LA	17025

A2LA = American Association for Laboratory Accreditation
ACLASS = ANSI-ASQ National Accreditation Board
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 a lathe from representative samples for 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 pages 2-3.

Traceability: The following Certified Reference Materials were used to validate the analytical data listed on page 2-3 — 11XSG2, 12X41300, 12X44220, 13X32100, 13X4101, 28X7138; 501-320, 501-501, 501-502, 501-503, 501-504, 501-643, 501-644, 501-646, 501-674, 501-676, 501-952, 501-991, 501-992, 501-993, 502-075, 502-102, 502-257, 502-403; AR 875; BAS 180/1, 180/2, 260/3, 261, 261/1, 331, 334, 345, 346A, 363, 363/1, 434, 464, 474; BS 400-1, 400-2, 400-3, 400B, 400C, 690; CZ 2015A; ECRM 281, 295-1, 296; IARM 51B, 51C, 52, 56C, 290A; IMZ 1.7/4, 1.12/3, 130, 132, 139, 169, 176A, 177, 178; SRM 162A, 866, 867, 882, 1244, 1249, 1361, 1365, 3103A, 3106, 3107, 3112A, 3128, 3131A, 3134, 3137, 3149, 3151, 3155, 3169, 9892A, 9892B, 9892C.

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 — BS CSN 2-1, CSN 4, 400-1, 400-2, 400-3, 400B, 400C; BAS 363/1; IARM 51C; SRM 106B, 864.

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 400D 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 ThyssenKrupp VDM, Werdohl, Germany

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 400D-110413. 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:

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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 November 04, 2013.

Beau R. Brammer