

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS 405A

Certified Reference Material for Monel Alloy R405 - UNS Number N04405

	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	Certified Values <sup>3</sup>	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>
<b>As</b>	<b>0.0004</b>	0.0002	<b>Ni</b>	<b>63.8</b>	0.2
<b>B</b>	<b>0.0007</b>	0.0003	<b>O</b>	<b>0.0007</b>	0.0002
<b>C</b>	<b>0.051</b>	0.002	<b>P</b>	<b>0.0037</b>	0.0007
<b>Co</b>	<b>0.019</b>	0.001	<b>Pb</b>	<b>0.0004</b>	0.0002
<b>Cr</b>	<b>0.0099</b>	0.0009	<b>S</b>	<b>0.041</b>	0.003
<b>Cu</b>	<b>32.1</b>	0.5	<b>Sn</b>	<b>0.0004</b>	0.0001
<b>Fe</b>	<b>1.51</b>	0.04	<b>Ti</b>	<b>0.0021</b>	0.0004
<b>Mn</b>	<b>1.90</b>	0.01	<b>W</b>	<b>0.0017</b>	0.0005
<b>Mo</b>	<b>0.0031</b>	0.0005	<b>Zr</b>	<b>0.012</b>	0.002
<b>Nb</b>	<b>0.0004</b>	0.0002			

	Reference Value	Estimate of Uncertainty	Reference Values <sup>3,4</sup>	Reference Value	Estimate of Uncertainty
<b>Mg</b>	<b>0.17</b>	0.02	<b>Si</b>	<b>0.15</b>	0.02

#### Informational Values<sup>3,5</sup>

Al (0.002)      Ca (0.00006)      N (0.001)      V (0.002)

<sup>1</sup> 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.

<sup>2</sup> 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.

<sup>3</sup> Values are given in weight percent. Values in brackets are reported by difference.

<sup>4</sup> Reference values are not certified and are provided for information only.

<sup>5</sup> Values in parentheses are not certified and are provided for information only.

Trace element information values for Hf 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.

## BS 405A

\* Code for method Certified values listed as weight percent

Analysis	*	As	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn
1	3	0.0002	4	0.0002	1	0.049	12	0.015667	5	0.008567	10	31.55	12	1.4	14	1.826667
2	4	0.000233	5	0.0004	1	0.050033	4	0.017333	14	0.009667	4	31.73667	4	1.45167	10	1.880
3	5	0.000283	4	0.0005	1	0.050567	10	0.018	10	0.01	10	31.86333	4	1.462	3	1.89
4	5	0.000283	12	0.000597	1	0.050767	4	0.018333	4	0.010067	12	32	4	1.47667	4	1.895333
5	12	0.000293	7	0.000603	1	0.0508	5	0.018333	4	0.0101	4	32.06433	4	1.492	4	1.896667
6	5	0.0005	4	0.000733	1	0.05185	14	0.019633	5	0.010233	4	32.07	4	1.496667	8	1.899
7	5	0.000733	3	0.00089	1	0.051967	4	0.0198	4	0.0103	6	32.104	4	1.498667	4	1.9034
8			4	0.0016	1	0.052133	4	0.019967	3	0.0107	4	32.19333	10	1.52	4	1.909
9					1	0.052267	4	0.0204	4	0.011067	13	32.20933	14	1.526667	4	1.91
10					1	0.0546	5	0.0218	5	0.011333	14	32.26667	16	1.536667	10	1.916667
11					3	0.0546	4	0.022	10	0.012	4	32.53333	4	1.538867	4	1.916667
12							8	0.022267			4	32.63377	3	1.58	4	1.929667
13											4	32.71333	10	1.59	4	1.96
14											3	32.86				
Average		0.000377		0.00069		0.0513		0.01940		0.00991		32.117		1.505374		1.9049
Std dev		0.000045		0.00011		0.0017		0.00090		0.00051		0.034		0.000088		0.0060
H		0.00026		0.00030		0.0016		0.0010		0.00074		0.18		0.014		0.016491
U <sub>1</sub>		0.00026		0.00032		0.0023		0.0013		0.00090		0.18		0.014		0.018
t-statistic		2.45		2.36		2.23		2.20		2.23		2.16		2.18		2.18
U <sub>2</sub>		0.00064		0.00075		0.0052		0.0030		0.0020		0.40		0.030		0.038
U <sub>3</sub>		0.00024		0.00026		0.0016		0.00080		0.00060		0.11		0.0080		0.011
<b>Certified</b>		<b>0.0004</b>		<b>0.0007</b>		<b>0.051</b>		<b>0.019</b>		<b>0.0099</b>		<b>32.1</b>		<b>1.51</b>		<b>1.90</b>
<b>Uncertainty</b>		<b>0.0002</b>		<b>0.0003</b>		<b>0.002</b>		<b>0.001</b>		<b>0.0009</b>		<b>0.5</b>		<b>0.04</b>		<b>0.01</b>
Tolerance		0.0004		0.0007		0.005		0.003		0.0027		0.9		0.12		0.04

Analysis	*	Mo	*	Nb	*	Ni	*	O	*	P	*	Pb	*	S	*	Sn
1	3	0.0027	12	0.000343	4	63.22333	2	0.00046	3	0.0026	3	0.0002	10	0.033	5	0.0003
2	5	0.002967	5	0.000347	16	[63.25]	2	0.0005	12	0.0027	5	0.0004	1	0.0342	3	0.0003
3	4	0.003167	5	0.00039	16	[63.4195]	2	0.0005	4	0.003067	12	0.00042	1	0.0356	12	0.000313
4	4	0.003267	4	0.0004	13	63.601	2	0.000592	4	0.0034	5	0.000467	12	0.038333	5	0.000333
5	5	0.0033	5	0.0004	4	63.63333	2	0.0006	4	0.003667	5	0.000483	1	0.039367	5	0.000397
6	5	0.003313	3	0.0004	4	63.73333	2	0.000633	5	0.0038	5	0.0005	10	0.04	5	0.0004
7	5	0.003367	5	0.000433	10	63.82	2	0.000673	4	0.004333	5	0.000513	1	0.041267	5	0.000417
8	14	0.003467			14	63.86667	2	0.000933	7	0.005227			1	0.041467	4	0.000433
9					4	63.89667	2	0.001123	5	0.0054			1	0.042067	4	0.000433
10					12	64							1	0.044333		
11					16	[64.00333]							1	0.046333		
12					16	[64.04]							1	0.0489		
13					10	64.16333							1	0.0513		
14					6	64.2										
Average		0.00312		0.000387		63.764		0.000697		0.00374		0.000419		0.041244		0.00037
Std dev		0.00027		0.000050		0.059		0.000060		0.00025		0.000046		0.000088		0.00011
H		0.00047		0.00026		0.35		0.00030		0.00050		0.00026		0.0014		0.00026
U <sub>1</sub>		0.00054		0.00026		0.35		0.00030		0.00056		0.00027		0.0014		0.00028
t-statistic		2.36		2.45		2.16		2.31		2.31		2.45		2.18		2.31
U <sub>2</sub>		0.0013		0.00064		0.76		0.00070		0.0013		0.00065		0.0031		0.00064
U <sub>3</sub>		0.00045		0.00024		0.20		0.00023		0.00043		0.00025		0.0009		0.00021
<b>Certified</b>		<b>0.0031</b>		<b>0.0004</b>		<b>63.8</b>		<b>0.0007</b>		<b>0.0037</b>		<b>0.0004</b>		<b>0.041</b>		<b>0.0004</b>
<b>Uncertainty</b>		<b>0.0005</b>		<b>0.0002</b>		<b>0.2</b>		<b>0.0002</b>		<b>0.0007</b>		<b>0.0002</b>		<b>0.003</b>		<b>0.0001</b>
Tolerance		0.0013		0.0004		0.8		0.0007		0.0021		0.0007		0.009		0.0003

**BS 405A** \* Code for method Certified values listed as weight percent

Analysis	*	Ti	*	W	*	Zr
1	12	0.0016	3	0.0009	12	0.005767
2	5	0.001767	12	0.001133	14	0.009567
3	5	0.0019	5	0.001707	5	0.010067
4	5	0.001907	5	0.001867	5	0.010567
5	4	0.001933	5	0.002067	10	0.011
6	4	0.002167	5	0.002067	4	0.011067
7	14	0.002467	4	0.002133	4	0.011333
8	3	0.0025	4	0.002233	5	0.011333
9	10	0.0026	4	0.002233	5	0.011767
10			14	0.002867	4	0.012967
11					4	0.0148
12					3	0.0149
13					4	0.014967
Average		0.00206		0.00174		0.011546
Std dev		0.00022		0.00019		0.000088
H		0.00041		0.00039		0.00079
U <sub>1</sub>		0.00046		0.00043		0.00079
t-statistic		2.31		2.26		2.18
U <sub>2</sub>		0.0011		0.0010		0.0017
U <sub>3</sub>		0.00035		0.00031		0.00050
<b>Certified</b>		<b>0.0021</b>		<b>0.0017</b>		<b>0.012</b>
<b>Uncertainty</b>		<b>0.0004</b>		<b>0.0005</b>		<b>0.002</b>
<b>Tolerance</b>		0.0011		0.0015		0.006

**BS 405A** \* Code for method Reference values listed as weight percent

Analysis	*	Mg	*	Si
1	10	0.14	12	0.12333
2	4	0.140333	10	0.133
3	3	0.14035	6	0.13767
4	4	0.150633	4	0.13825
5	12	0.1700	14	0.14033
6	14	0.170667	3	0.146
7	10	0.176667	4	0.147
8	4	0.19	4	0.15
9	4	0.192333	10	0.15
10	4	0.193333	5	0.15337
11	4	0.198267	4	0.17333
12	5	0.199167	4	0.17667
13			4	0.18687
Average		0.171813		0.150447
Std dev		0.000091		0.000088
H		0.003205		0.002959
U <sub>1</sub>		0.0032		0.0030
t-statistic		2.20		2.18
U <sub>2</sub>		0.071		0.0065
U <sub>3</sub>		0.0020		0.0018
<b>Reference</b>		<b>0.17</b>		<b>0.15</b>
<b>Uncertainty</b>		<b>0.02</b>		<b>0.02</b>
<b>Tolerance</b>		0.05		0.04

**BS 405A** \* Code for method Informational values listed as weight percent

Analysis	*	Al	*	Ca	*	N	*	V
1	5	0.00082	12	0.000059	2	0.0001	12	0.000683
2	4	0.001			2	0.000277	5	0.0007
3	5	0.001367			2	0.0004	5	0.000733
4	4	0.001533			2	0.003333	5	0.000777
5	12	0.0018					5	0.001567
6	5	0.0020					3	0.0029
7	4	0.002133					4	0.003267
8	14	0.0030					4	0.0033
9	3	0.0034						
10	4	0.003733						
11	4	0.006						
Average		0.0024		0.000059		0.0010		0.0017
Std dev		0.0099		0.000015		0.0039		0.0068
H		0.0004		0.00019		0.0003		0.0004
U <sub>1</sub>		0.0099		0.00019		0.0039		0.0068
t-statistic		2.23		12.71		3.18		2.36
U <sub>2</sub>		0.022		0.0024		0.012		0.016
U <sub>3</sub>		0.0066		0.0024		0.0062		0.0057
<b>(Informational)</b>		<b>(0.002)</b>		<b>(0.00006)</b>		<b>(0.001)</b>		<b>(0.002)</b>

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<sub>L</sub>), calculated from its standard deviation (S<sub>L</sub>) and its uncertainty estimate (U<sub>L</sub>), is used as the weight (W<sub>L</sub>) for its mean (M<sub>L</sub>). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U<sub>1</sub> is the combined uncertainty from homogeneity and labs. U<sub>2</sub> is U<sub>1</sub> multiplied by the coverage factor (95 % t-statistic). U<sub>3</sub> is U<sub>2</sub> 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 U<sub>3</sub> 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 405A** \* Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Hf	*	Zn
1	5	2	5	6
2	5	2	5	9
3	5	2	5	9

### 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	
6 Gravimetric	12 GD Mass Spectrometry	

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

<u>Laboratory</u>	<u>Location</u>	<u>Registrar</u>	<u>Accreditation</u>
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Evans Analytical Group	Liverpool, NY	A2LA	17025
Dirats Laboratories	Westfield, MA	ACCLASS	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Central Iron and Steel Research Institute	Beijing, China	CNAS	17025
Exova	Glendale Heights, IL	A2LA	17025

A2LA = American Association for Laboratory Accreditation  
ACCLASS = 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 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, 12X32550, 13X32101A, 14XMN1, 14XMN3, 212X4001, 212X4003, 212X4005, 212X4005D, 215XHB2; LECO 501-320, 501-501, 501-502, 501-644, 501-646, 501-676, 501-993, 502-416, 502-873; AR 115C, 512, 644, 654, 662, 871, 875, 891, 892, 1651, 1652, 1653; BAS 152/2, 345, 351, 363, 363/1, 387, 403, 434, 435; BS 50C, 181A, 304, 400, 400-2, 400-3, 400D, 405, 800, 8620C; ECRM 85, 86, 87, 285-2; IARM 51C, 52A, 56C, 202A; IMZ 1.12/3, 112, 121, 124, 1-N4; KMS LCSON-001; MQ CA01A; NCS NS11028; SRM C1248, 8F, 160B, 162A, 363, 866, 882, 1413, 3103A, 3107, 3112A, 3128, 3131A, 3134, 3161A.

**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 — LECO 501-676, 502-873; BAS 351, 363/1; BS 400, 400-2, 400-3, 405, 500C; IARM 51C; KMS LCSON-001; MQ CA01a; NCS NS11028; SRM 160B, 882.

**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 405A 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 Deutsche Nickel GMBH; Schwerte, 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, 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 405A-091516. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://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](http://www.brammerstandard.com)**  
**14603 Benfer Road**  
**Houston, Texas 77069-2895 USA**              **Fax: (281) 440-4432**              **Email: [contact@brammerstandard.com](mailto: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](http://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 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](http://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 15, 2016.

Beau R. Brammer