

BRAMMER STANDARD COMPANY, INC.

Certificate of Analysis

BS 422

Certified Reference Material for Stainless Steel Grade 422 - UNS Number S42200

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.0135	0.0006	S	0.0013	0.0002
As	0.0041	0.0008	Si	0.404	0.005
C	0.232	0.003	Sn	0.0043	0.0004
Ca	0.0031	0.0004	Ti	0.0011	0.0003
Co	0.0293	0.0008	V	0.274	0.006
Cr	11.25	0.09	W	0.95	0.04
Cu	0.080	0.002			
Fe	84.5	0.3			
Mn	0.640	0.004			
Mo	0.896	0.009			
N	0.050	0.001			
Nb	0.045	0.002			
Ni	0.676	0.008			
O	0.0030	0.0003			
P	0.0169	0.0006			

Informational Values^{3,4}

B (0.0002)	Mg (0.0009)	Pb (0.00005)	Sb (0.0007)	Ta (0.0001)
Zr (0.001)				

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 4 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 4 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, Cl, Ga, Ge, K, Na, Re, 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 422 * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe
1	5	0.010067	5	0.002867	3	0.22525	4	0.002767	4	0.027	4	10.55	5	0.074633	16	[84.22667]
2	4	0.012	15	0.00308	1	0.23	4	0.0028	3	0.02715	13	11.07167	10	0.075	10	84.29
3	12	0.0125	12	0.0033	3	0.23	4	0.0028	10	0.028333	4	11.12867	3	0.076067	3	84.38
4	5	0.012667	5	0.003333	1	0.230033	4	0.003067	4	0.0286	3	11.15	12	0.0770	4	84.41667
5	3	0.013	5	0.003433	1	0.232667	4	0.003133	4	0.0287	10	11.15227	8	0.077367	16	[84.44397]
6	3	0.013425	5	0.003833	1	0.232667	12	0.0034	3	0.029	10	11.165	10	0.077633	10	84.44667
7	4	0.0136	5	0.004767	1	0.233333	14	0.0034	5	0.0292	10	11.16667	10	0.0788	16	[84.48333]
8	4	0.013767	4	0.004967	1	0.234	12	0.0034	4	0.0292	14	11.17333	4	0.0789	14	84.52333
9	4	0.014233	3	0.005	1	0.235333	3	0.003595	10	0.03	3	11.19667	4	0.078967	16	[84.62]
10	14	0.014433	4	0.0051	1	0.237			12	0.0300	4	11.21727	4	0.079533	16	[84.62]
11	4	0.014633	9	0.0052	1	0.2376			14	0.030233	4	11.22333	3	0.0798	13	84.71567
12	5	0.0149			1	0.238333			4	0.0306	3	11.23	4	0.08	4	84.83333
13					1	0.239167			4	0.0314	4	11.24657	14	0.080333		
14					1	0.241333			8	0.031433	4	11.25667	4	0.081667		
15									5	0.031533	4	11.29667	3	0.082		
16									5	0.033533	10	11.34	5	0.0822		
17									3	0.0338	4	11.4	4	0.082767		
18													4	0.0835		
19													5	0.0854		
Average		0.01350		0.00407		0.2322		0.00310		0.0293		11.2464		0.0798		84.510
Std dev		0.00055		0.00022		0.0037		0.00022		0.0011		0.0039		0.0020		0.041
H		0.00079		0.00049		0.0036		0.00044		0.0011		0.070		0.0019		0.48
U ₁		0.00096		0.00053		0.0052		0.00049		0.0016		0.070		0.0028		0.48
t-statistic		2.20		2.23		2.16		2.31		2.12		2.12		2.10		2.20
U ₂		0.0021		0.0012		0.011		0.0011		0.0034		0.15		0.0059		1.06
U ₃		0.00061		0.00036		0.0030		0.00038		0.00083		0.036		0.0013		0.31
Certified		0.0135		0.0041		0.232		0.0031		0.0293		11.25		0.080		84.5
Uncertainty		0.0006		0.0008		0.003		0.0004		0.0008		0.09		0.002		0.3
Tolerance		0.0021		0.0012		0.011		0.0011		0.0034		0.15		0.006		1.1

Analysis	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	S
1	10	0.603333	5	0.7249	2	0.0480	5	0.040033	10	0.663333	2	0.001333	10	0.011867	1	0.0009
2	4	0.619333	4	0.8538	2	0.0481	4	0.042267	4	0.664333	2	0.002723	3	0.012367	1	0.0011
3	10	0.63	4	0.874	2	0.048687	4	0.0424	10	0.666	2	0.0028	4	0.0150	1	0.0011
4	4	0.631667	4	0.89	2	0.0491	4	0.042767	4	0.668667	2	0.002933	10	0.0163	1	0.001167
5	10	0.632067	4	0.895467	2	0.049367	10	0.043	4	0.669	2	0.002967	4	0.016467	1	0.0012
6	3	0.63475	10	0.897	2	0.0497	4	0.043667	3	0.67	2	0.003133	4	0.0165	1	0.0013
7	4	0.636333	14	0.900	2	0.049733	3	0.044	4	0.670133	2	0.00335	7	0.016533	12	0.0013
8	10	0.638667	3	0.900	2	0.050233	10	0.044	14	0.672333	2	0.0035	4	0.016667	1	0.001367
9	4	0.639333	3	0.902	2	0.050567	4	0.0442	4	0.6753	2	0.003533	3	0.016725	1	0.001567
10	8	0.639667	3	0.90225	2	0.05138	14	0.0450	4	0.676667	2	0.003577	4	0.0168	1	0.00171
11	3	0.64	4	0.903333	2	0.051667	5	0.0454	3	0.68275	2	0.004073	14	0.016967	1	0.001967
12	14	0.640667	10	0.904933	2	0.053333	4	0.046233	4	0.685			12	0.0170	3	0.002
13	4	0.643667	4	0.905667			12	0.0470	3	0.686667			10	0.017	1	0.0022
14	4	0.646667	10	0.906667			3	0.049325	10	0.688333			4	0.0180	10	0.0024
15	4	0.6468	4	0.907			5	0.050533	10	0.689333			3	0.018	3	0.003375
16	4	0.648667	4	0.907333					8	0.690667			5	0.018933		
17	3	0.665333	10	0.914					4	0.703333			5	0.0203		
18	4	0.666667	4	0.9289					5	0.706967						
Average		0.6403		0.8965		0.0503		0.0455		0.6761		0.00297		0.01689		0.001305
Std dev		0.0052		0.0053		0.0016		0.0015		0.0058		0.00014		0.00078		0.000084
H		0.0071		0.009		0.0015		0.0014		0.0074		0.00043		0.0009		0.00034
U ₁		0.0088		0.011		0.0022		0.0021		0.0094		0.00046		0.0012		0.00035
t-statistic		2.11		2.11		2.20		2.14		2.11		2.23		2.12		2.14
U ₂		0.019		0.022		0.0048		0.0045		0.020		0.0010		0.0025		0.00074
U ₃		0.0044		0.0052		0.0014		0.0012		0.0047		0.00031		0.00060		0.00019
Certified		0.640		0.896		0.050		0.045		0.676		0.0030		0.0169		0.0013
Uncertainty		0.004		0.009		0.001		0.002		0.008		0.0003		0.0006		0.0002
Tolerance		0.019		0.022		0.005		0.004		0.020		0.0010		0.0025		0.0007

BS 422 * Code for method Certified values listed as weight percent

Analysis	*	Si	*	Sn	*	Ti	*	V	*	W
1	4	0.391667	5	0.002733	5	0.000603	10	0.25	4	0.876
2	4	0.392667	5	0.003333	5	0.0008	4	0.2578	10	0.876133
3	4	0.395	12	0.0040	12	0.0009	10	0.263567	10	0.881
4	4	0.397	9	0.004033	5	0.0010	10	0.267333	10	0.907
5	3	0.3975	5	0.00419	5	0.001167	5	0.268667	4	0.9188
6	14	0.398667	5	0.004533	4	0.0014	4	0.27	14	0.921
7	10	0.399	4	0.004667	4	0.00188	3	0.270333	10	0.926667
8	4	0.399	5	0.004967			7	0.271	3	0.93
9	10	0.40	5	0.005267			4	0.274667	4	0.931433
10	3	0.40					3	0.2775	4	0.932667
11	6	0.403333					12	0.2800	4	0.958667
12	4	0.4047					3	0.28	3	1.00
13	5	0.404967					10	0.28	4	1.00
14	10	0.408433					14	0.281333	10	1.00
15	4	0.417067					4	0.2825		
16	3	0.417333					4	0.282667		
17	4	0.42					4	0.285667		
18	4	0.446667					4	0.287667		
19	12	0.4500					5	0.305233		
20							5	0.311667		
Average		0.4040		0.00431		0.00107		0.2743		0.9513
Std dev		0.0047		0.00020		0.00010		0.0039		0.0069
H		0.0052		0.00050		0.00032		0.0040		0.009
U ₁		0.0070		0.00053		0.00033		0.0056		0.012
t-statistic		2.10		2.31		2.45		2.09		2.16
U ₂		0.015		0.0012		0.00082		0.012		0.025
U ₃		0.0034		0.00041		0.00031		0.0026		0.0068
Certified		0.404		0.0043		0.0011		0.274		0.95
Uncertainty		0.005		0.0004		0.0003		0.006		0.04
Tolerance		0.015		0.0012		0.0008		0.012		0.13

BS 422 * Code for method Informational values listed as weight percent

Analysis	*	B	*	Mg	*	Pb	*	Sb	*	Ta	*	Zr
1	5	0.0000433	5	0.000773	5	0.0000397	5	0.0006	5	0.0001	5	0.0000867
2	12	0.000060	5	0.000833	12	0.000056	5	0.0006	12	0.00017	3	0.000375
3	3	0.0002	12	0.0010			5	0.000757			12	0.0015
4	4	0.0002667					5	0.000767			5	0.0018667
5	3	0.0004					12	0.00090				
Average		0.00019		0.0009		0.0000478		0.0007		0.000135		0.0010
Std dev		0.00011		0.0034		0.0000054		0.0019		0.000077		0.0036
H		0.00022		0.0003		0.00019		0.0003		0.00021		0.0003
U ₁		0.00025		0.0034		0.00019		0.0019		0.00022		0.0036
t-statistic		2.78		4.30		12.71		2.78		12.71		3.18
U ₂		0.00068		0.015		0.0024		0.0053		0.0028		0.011
U ₃		0.00031		0.0086		0.0017		0.0024		0.0020		0.0057
(Informational)		(0.0002)		(0.0009)		(0.00005)		(0.0007)		(0.0001)		(0.001)

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 its 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 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 422 * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis *	Bi *	Cl *	Ga *	Ge *	K *	Na *	Re *	Zn *
1	12 0.021	12 0.032	12 21	5 3	12 0.25	12 0.29	12 0.85	12 2.5
2			5 27	5 4			5 1.3	5 9
3			5 27	5 5			5 1.4	5 10
4			5 27	5 11			5 1.4	5 13
5				5 11				
6				5 12				
7				12 17				

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

Laboratory

Brammer Standard Company, Inc.
 LECO Corporation

Location

Houston, TX
 St. Joseph, MI

Registrar

A2LA
 A2LA

Accreditation

17025, Guide 34
 17025

Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895
Telephone: (281) 440-9396 Fax: (281) 440-4432 Website: www.brammerstandard.com
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Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Dirats Laboratories	Westfield, MA	ACCLASS	17025
NSL Analytical	Cleveland, OH	ACCLASS	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Evans Analytical Group	Liverpool, NY	A2LA	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	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: 12X353, 12X356, 12X52986, 13X14212, 13X31254, 13X41001, 13X43100; 501-320, 501-501, 501-502, 501-503, 501-504, 501-644, 501-676, 501-911, 501-992, 501-993, 502-257, 502-328, 502-348, 502-416, 502-494, 502-869; AR 148, 645, 654, 657, 659, 673, 688, 875, 960, 1647, 1652, 1656, 4100; BAS 69, 72, 464/4; BS 30D, 37D, 48, 56H, 90F, 97, 316C, 316E, 410C, 1030, 2205, 4130; ECRM 85-1, 86-1, 87-1; IARM 41C, 42B, 205B; IMZ 1.85, 112, 156, 161, 171, 503; IPT 208Fe; JK 37; SRM 16F, 36, 55D, 101D, 101E, 133B, 155, 160B, 342, 343A, 345, 348, 361, 362, 363, 460, 1246, 1249, 1263A, 1264A, 1413, 1763A, 2159, 2166, 3109A, 3155, 3169.

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 — 501-676, 502-257; AR 4100; BS HON-T, 37D, 48, 90F; ECRM 096-1, 532-1; IARM 205B; IMZ 161; NCS NS21006.

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 422 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 Bohler Edelstahl; Kapfenberg, Austria.

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.

Certificate Number: The unique identification number for this certificate of analysis is 422-092315. 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. Phone: (281) 440-9396 Web: www.brammerstandard.com

Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895
Telephone: (281) 440-9396 Fax: (281) 440-4432 Website: www.brammerstandard.com
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14603 Benfer Road

Houston, Texas 77069-2895 USA

Fax: (281) 440-4432

Email: 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

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 30:1992 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

Certified by: _____ on September 23, 2015.

Beau R. Brammer