Brammer Standard Company, Inc.

Certificate of Analysis

BS 9325A

Certified Reference Material for Low Alloy Steel

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.0056**	0.0005	**Mo**	**0.358**	0.007
As	**0.0024**	0.0002	**N**	**0.0076**	0.0006
C	**0.203**	0.002	**Nb**	**0.0017**	0.0003
Ca	**0.0039**	0.0006	**Ni**	**3.29**	0.02
Co	**0.0093**	0.0004	**P**	**0.0079**	0.0005
Cr	**1.50**	0.01	**S**	**0.0045**	0.0003
Cu	**0.163**	0.003	**Si**	**0.612**	0.008
Fe	**92.8**	0.4	**Ti**	**0.0030**	0.0006
Mn	**0.969**	0.009	**W**	**0.024**	0.002

Reference Values[3,4]

	Reference Value[1]	Estimate of Uncertainty[2]		Reference Value[1]	Estimate of Uncertainty[2]
V	**0.0024**	0.0002			

Informational Values[3,5]

B (0.0001) Mg (0.0002) Pb (0.0003) Sn (0.0003) Ta (0.010)
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] 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 O 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 9325A * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe
1	5	0.004233	5	0.001167	1	0.184333	3	0.0029	4	0.00870	3	1.416667	5	0.152	13	92.490
2	3	0.0044	15	0.00182	3	0.199	3	0.00307	4	0.008767	10	1.472	4	0.15625	4	92.70
3	4	0.004533	4	0.00206	1	0.199667	4	0.00350	4	0.008833	4	1.474	4	0.15875	16	[92.7513]
4	14	0.005133	4	0.0021	3	0.20	4	0.003533	4	0.008875	3	1.48	3	0.159333	16	[92.82]
5	3	0.0053	4	0.002143	1	0.2005	4	0.003775	3	0.0091	14	1.486667	10	0.161667	10	92.84333
6	4	0.0053	4	0.002425	1	0.200667	4	0.003965	4	0.0091	3	1.49	4	0.16225	16	[92.87]
7	7	0.005615	5	0.002467	1	0.200893	18	0.00398	4	0.009305	4	1.49	4	0.162667	16	[92.88667]
8	4	0.00580	4	0.002488	1	0.20125	4	0.00411	4	0.009333	13	1.495	4	0.162667	14	92.9
9	5	0.00580	10	0.0025	1	0.201333	4	0.004175	4	0.009345	10	1.50	4	0.162667	3	93.06667
10	4	0.0060	5	0.002533	1	0.2024	4	0.004175	4	0.009367	4	1.503167	18	0.16325		
11	7	0.00606	9	0.002567	1	0.202667	4	0.004333	3	0.0096	4	1.5035	4	0.164667		
12	7	0.006183	4	0.002767	17	0.2030	14	0.004533	14	0.009667	4	1.50775	4	0.16525		
13	7	0.00650	3	0.0028	1	0.20425	4	0.004567	4	0.009707	13	1.50775	14	0.165667		
14	4	0.010833	4	0.00285	1	0.2045	4	0.004567	8	0.009863	4	1.50825	4	0.165833		
15	3	0.011967	4	0.00330	1	0.205	4	0.004567	4	0.009925	4	1.510	3	0.166		
16					1	0.2055	4	0.004667	5	0.0100	13	1.516333	8	0.1665		
17					1	0.209433					4	1.5170	8	0.167333		
18											4	1.520333	7	0.168333		
19											7	1.5205	10	0.169		
20													3	0.170		
Average		0.00555		0.002436		0.2030		0.00395		0.00934		1.5041		0.1634		92.843
Std dev		0.00019		0.000074		0.0028		0.00011		0.00027		0.0038		0.0026		0.041
H		0.00055		0.00041		0.0034		0.00049		0.00068		0.013		0.0030		0.51
U_1		0.00058		0.00042		0.0044		0.00050		0.00073		0.014		0.0040		0.51
t-statistic		2.14		2.14		2.12		2.13		2.13		2.10		2.09		2.31
U_2		0.0013		0.00089		0.0094		0.0011		0.0016		0.029		0.0083		1.19
U_3		0.00032		0.00023		0.0023		0.00027		0.00039		0.0070		0.0019		0.40
Certified		**0.0056**		**0.0024**		**0.203**		**0.0039**		**0.0093**		**1.50**		**0.163**		**92.8**
Uncertainty		**0.0005**		**0.0002**		**0.002**		**0.0006**		**0.0004**		**0.01**		**0.003**		**0.4**
Tolerance		0.0015		0.0009		0.009		0.0018		0.0016		0.03		0.009		1.2

Analysis	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	P	*	S	*	Si
1	3	0.927667	3	0.315333	13	0.00718	7	0.00159	3	3.24	5	0.0056	1	0.003733	10	0.565667
2	14	0.941333	5	0.321333	13	0.00756	4	0.001608	6	3.25675	7	0.00697	1	0.003767	3	0.597333
3	3	0.942	4	0.332	13	0.0077	7	0.001633	7	3.272	4	0.0074	1	0.004023	3	0.60
4	4	0.950	10	0.336667	13	0.00765	4	0.001698	4	3.272333	4	0.007533	1	0.004233	7	0.60025
5	7	0.956333	4	0.346767	13	0.00779	4	0.001823	4	3.27475	4	0.00772	1	0.004267	4	0.600667
6	4	0.957267	3	0.35	2	0.007767	4	0.001925	4	3.292	7	0.007925	1	0.004333	4	0.604
7	4	0.959333	3	0.351	13	0.00814	4	0.002333	4	3.296333	4	0.008033	1	0.004518	14	0.607
8	3	0.96	10	0.351			3	0.0052	3	3.3	4	0.008075	1	0.00453	7	0.608
9	10	0.961	4	0.351667			4	0.005367	4	3.301	4	0.00817	1	0.00459	3	0.6080
10	4	0.966	14	0.353			14	0.005567	4	3.304	4	0.008187	1	0.004633	4	0.6083
11	8	0.968	7	0.355333					13	3.305	19	0.00820	1	0.004653	4	0.615
12	4	0.970	4	0.3575					10	3.31	10	0.0083	1	0.004667	7	0.6155
13	4	0.97025	4	0.35925					14	3.313333	4	0.008518	1	0.004698	7	0.6165
14	4	0.97225	4	0.36025					10	3.316667	14	0.008633	1	0.0051	4	0.619
15	4	0.972533	4	0.360333					7	3.33225	4	0.008733	1	0.005327	6	0.620333
16	18	0.9755	4	0.363					4	3.335067	3	0.0088	3	0.0061	4	0.622
17	8	0.9755	4	0.3639					3	3.35	3	0.009567			4	0.623967
18	7	0.98325	4	0.364					4	3.354667	10	0.010067			4	0.625333
19	4	0.984	4	0.3760					4	3.486667					10	0.63
20	10	0.997667														
Average		0.9692		0.3582		0.00763		0.001733		3.2914		0.00789		0.00449		0.6123
Std dev		0.0040		0.0034		0.00027		0.000077		0.0041		0.00025		0.00012		0.0039
H		0.010		0.0049		0.00063		0.00037		0.025		0.00064		0.00051		0.00705
U_1		0.011		0.0060		0.00068		0.00037		0.025		0.00068		0.00052		0.0081
t-statistic		2.09		2.10		2.45		2.26		2.10		2.11		2.13		2.10
U_2		0.022		0.013		0.0017		0.00085		0.053		0.0014		0.0011		0.017
U_3		0.0049		0.0029		0.00063		0.00027		0.012		0.00034		0.00028		0.0039
Certified		**0.969**		**0.358**		**0.0076**		**0.0017**		**3.29**		**0.0079**		**0.0045**		**0.612**
Uncertainty		**0.009**		**0.007**		**0.0006**		**0.0003**		**0.02**		**0.0005**		**0.0003**		**0.008**
Tolerance		0.027		0.021		0.0017		0.0008		0.06		0.0015		0.0011		0.024

BS 9325A * Code for method Certified values listed as weight percent

Analysis	*	Ti	*	W
1	4	0.001693	3	0.0223
2	4	0.001695	14	0.022333
3	4	0.002063	4	0.024067
4	4	0.00250	4	0.025467
5	5	0.0027	4	0.0260
6	5	0.002993	4	0.026533
7	4	0.003065	5	0.029133
8	4	0.0031	10	0.029167
9	5	0.0031		
10	3	0.003233		
11	4	0.003367		
12	4	0.003433		
13	4	0.00345		
14	3	0.0036		
15	14	0.003633		
16	10	0.003867		
17	10	0.0039		
18	3	0.0042		
Average		0.00297		0.0244
Std dev		0.00010		0.0012
H		0.00044		0.0011
U_1		0.00045		0.0016
t-statistic		2.11		2.36
U_2		0.0010		0.0038
U_3		0.00022		0.0013
Certified		**0.0030**		**0.024**
Uncertainty		**0.0006**		**0.002**
Tolerance		0.0018		0.006

BS 9325A * Code for method Reference values listed as weight percent

Analysis	*	V
1	5	0.000647
2	5	0.0010
3	5	0.001217
4	4	0.001333
5	3	0.0016
6	4	0.0016
7	14	0.001667
8	10	0.0017
9	4	0.002433
10	13	0.00260
11	4	0.002615
12	4	0.00263
13	4	0.002675
14	4	0.00283
Average		0.002449
Std dev		0.000049
H		0.00041
U_1		0.00041
t-statistic		2.16
U_2		0.00089
U_3		0.00024
Reference		**0.0024**
Uncertainty		**0.0002**
Tolerance		0.0009

BS 9325A * Code for method Informational values listed as weight percent

Analysis	*	B	*	Mg	*	Pb	*	Sn	*	Ta	*	Zr
1	4	0.0001	5	0.000033	5	0.0000567	4	0.00012	4	0.009467	5	0.0000433
2			4	0.000103	4	0.00007	4	0.000128			4	0.0005
3			3	0.00011	4	0.0000775	4	0.000133			4	0.0010333
4			5	0.000167	4	0.000095	5	0.000133			10	0.0019
5			4	0.000527	4	0.0000975	5	0.000143			3	0.0021
6					4	0.00010	5	0.000177				
7					4	0.000135	5	0.000267				
8					5	0.0003	3	0.0003				
9					9	0.00037	4	0.000328				
10					4	0.0006667	4	0.00040				
11					10	0.0007	4	0.000443				
12					3	0.0007	4	0.000778				
13							9	0.000833				
Average		0.000100		0.00019		0.00028		0.00032		0.01		0.0011
Std dev		0.000055		0.00011		0.00017		0.00022		0.21		0.0040
H		0.00019		0.00021		0.00023		0.00024		0.00		0.0003
U_1		0.00020		0.00024		0.00029		0.00032		0.21		0.0040
t-statistic		12.71		2.78		2.20		2.18		12.71		2.78
U_2		0.0026		0.00067		0.00063		0.00070		2.69		0.011
U_3		0.0026		0.00030		0.00018		0.00020		2.69		0.0050
(Informational)		**(0.0001)**		**(0.0002)**		**(0.0003)**		**(0.0003)**		**(0.010)**		**(0.001)**

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 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 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 9325A * Code for analytical method Trace analysis listed as mg/kg (ppm)

	*	O	*	*	*	*	*	*	*	*	*
1	2	6.933									

Analytical Method Codes:

1	Combustion (ASTM E1019)	8	Flame Atomic Absorption	15	HG Atomic Fluorescence
2	Fusion (ASTM E1019)	9	GF Atomic Absorption	16	Difference
3	Spark Atomic Emission	10	X-Ray Fluorescence	17	Volumetric
4	ICP Atomic Emission	11	GD Atomic Emission	18	Atomic Absorption Spectrometry
5	ICP Mass Spectrometry	12	GD Mass Spectrometry	19	RMP
6	Gravimetric	13	Titrimetric		
7	Photometric	14	DCP Atomic Emission		

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

Laboratory	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
LECO Corporation	St. Joseph, MI	A2LA	17025
NSL Analytical	Cleveland, OH	ACLASS	17025
Dirats Laboratories	Westfield,MA	ACLASS	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Exova	Glendale Heights, Il	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Taiyuan Iron & Steel Co., Ltd.	Taiyuan, China	CNAS	17025
Wuhan Iron & Steel Co., Ltd.	Wuhan, China	CNAS	17025
Shanghai Research Institute of Materials	Shanghai, China	CNAS	17025
Panzhihua Iron & Steel	Panzhihua, China	CNAS	17025
Jinan Zhongbiao Scientific Co., Ltd.	Jinan, China	CNAS	17025
Shijiazhuang Trump Scientific Co., Ltd	Shijiazhuang, China	CNAS	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 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: 12X32550, 13X31254, 13X32101; 501-320, 501-501, 501-503, 501-504, 501-550, 501-644, 501-673, 501-676, 501-993, 502-414, 502-873; AR 148, 642, 872, 875, 1653; BAS 409, 409/1, 434, 434/2, 435, 464/1, 613/1, 614/1; BS 13, 30D, 56H, 210, 213, 300, 1026, 1030, 1972; ECRM 184-1; IARM 16C, 29B, 35H, 156B, 210C; IMZ 55/1, 58/1, 130, 139; JK Nr8F, 37; JSS 517-3; SRM 16F, 72F, 72G, 160B, 170B, 361, 362, 363, 364, 691, 1228, 1261, 3109A, 3113, 3131A, 3163, 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; BAS 613/1, 614/1; BS 13, 210, 213, 1972; ECRM 184-1; JSS 517-3; SRM 72G, 291.

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 9325A is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

Source: The **cast** stock for this CRM was produced by Jey Swen Enterprises; Kaohsiung, Taiwan.
Form: This CRM is machined in the form of a disc, approximately 40 mm in diameter and 30 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 certified area of each disc is the portion extending several mm inward from each surface.

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 **9325A-030916**. 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**
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, 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 March 9, 2016.

Beau R. Brammer