

Brammer Standard Company, Inc.

Certificate of Analysis

BS 1763

Certified Reference Material for Low Alloy Steel

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.051	0.006		Mo	0.04
As	0.066	0.008		N	0.0007
B	0.0031	0.0007		Nb	0.009
C	0.271	0.009		Ni	0.02
Co	0.124	0.008		O	0.001
Cr	0.560	0.009		P	0.002
Cu	0.175	0.008		Pb	0.0006
Fe	94.6	0.1		S	0.002
H	0.0003	0.0001		Si	0.03
Mg	0.0002	0.0001		Ti	0.04
Mn	1.50	0.03		V	0.007
	Reference Value ¹	Estimate of Uncertainty ²	Reference Values^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
Ca	<0.05			Ta	0.009
Sb	0.019	0.007		W	<0.05
Sn	0.013	0.003		Zr	0.009

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.

Trace element information values for Zn are shown on page 4.

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	*	As	*	B	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	H	*	Mg
1	5	0.0455	4	0.0499	4	0.002267	1	0.241367	3	0.112667	4	0.544667	4	0.167133	16	[94.489]	2	0.0001	4	0.0001
2	3	0.0471	4	0.058833	3	0.002367	11	0.262	4	0.1182	4	0.545967	10	0.169	4	94.534367	2	0.000135	4	0.0001967
3	4	0.0486333	10	0.059	3	0.0024	11	0.266667	3	0.119	4	0.549667	5	0.169	16	[94.56]	2	0.0002	3	0.0002
4	4	0.0490333	5	0.060333	14	0.002667	3	0.267	3	0.119333	4	0.552	10	0.17	16	[94.56]	2	0.000247	4	0.0002
5	3	0.05	4	0.061167	4	0.002867	1	0.268667	4	0.119967	11	0.553333	3	0.171	16	[94.56]	2	0.000253	4	0.0004133
6	3	0.0500333	4	0.064067	4	0.003	1	0.269	10	0.12	11	0.556	4	0.1712	14	94.6	2	0.0003		
7	11	0.0500667	3	0.064233	11	0.0031	1	0.269667	14	0.120333	4	0.556333	8	0.171333	4	94.6	2	0.0003		
8	11	0.0506	4	0.064667	3	0.003233	3	0.27	4	0.120367	3	0.557	4	0.171333	16	[94.6]	2	0.00033		
9	4	0.0506667	3	0.067	11	0.0033	3	0.270333	4	0.122	10	0.557	4	0.173333	13	94.609667	2	0.000333		
10	3	0.0513333	4	0.0674	5	0.003433	1	0.270933	4	0.122	4	0.557497	4	0.174333	16	[94.616]	2	0.000357		
11	3	0.0518	11	0.071267	3	0.0035	3	0.272	11	0.123	4	0.559867	11	0.176333	10	94.616667				
12	4	0.0519667	4	0.072	7	0.003663	1	0.272	5	0.123667	3	0.56	3	0.176667	16	[94.6181]				
13	4	0.0520333	4	0.072233	4	0.0037	1	0.272	4	0.1253	4	0.560133	11	0.178	16	[94.643934]				
14	14	0.0522	14	0.073233	5	0.003747	1	0.273367	11	0.125667	3	0.562	14	0.178	16	[94.7]				
15	4	0.0522667	3	0.0745	4	0.003767	1	0.277333	4	0.125737	3	0.562667	3	0.179333	4	94.716667				
16	4	0.0532333	4	0.075733			1	0.283	4	0.127667	14	0.563333	3	0.18						
17	4	0.0545	11	0.0769			1	0.286733	10	0.129	3	0.565333	4	0.18						
18							1	0.293333	8	0.129667	4	0.566433	4	0.180067						
19									3	0.13	10	0.57	3	0.180333						
20									4	0.130333	4	0.573333	4	0.1859						
21									3	0.132										
Average		0.0510		0.0662		0.003026		0.2709		0.1243		0.5603		0.1757		94.608		0.000212		0.0001969
Std Dev		0.0013		0.0018		0.000090		0.0032		0.0023		0.0036		0.0026		0.023		0.000012		0.0000070
H		0.0023		0.0026		0.000655		0.0053		0.0035		0.0078		0.0042		0.186421		0.000247		0.00024
U ₁		0.0026		0.0032		0.00066		0.0062		0.0042		0.0086		0.0050		0.19		0.00025		0.00024
t-statistic		2.12		2.12		2.14		2.11		2.09		2.09		2.09		2.14		2.26		2.78
U ₂		0.0056		0.0067		0.0014		0.013		0.0088		0.018		0.010		0.40		0.00056		0.00067
U ₃		0.0014		0.0016		0.00037		0.0031		0.0019		0.0040		0.0023		0.10		0.00018		0.00030
Certified		0.051		0.066		0.0031		0.271		0.124		0.560		0.175		94.6		0.0003		0.0002
Uncertainty		0.006		0.008		0.0007		0.009		0.008		0.009		0.008		0.1		0.0001		0.0001
Tolerance		0.018		0.024		0.0021		0.027		0.024		0.027		0.024		0.3		0.0002		0.0001

Analysis	*	Mn	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	Pb	*	S	*	Si	
1	3	1.4733333	4	0.502	2	0.009493	11	0.126	3	0.519	2	0.006367	5	0.010967	5	0.0018733	1	0.021733	3	0.6493333	
2	3	1.48	4	0.517667	2	0.009533	14	0.129333	4	0.526	2	0.0069	4	0.012667	5	0.0020	1	0.0219	4	0.6526667	
3	4	1.4893333	4	0.537	3	0.0097	11	0.133667	4	0.529933	2	0.007233	5	0.013767	3	0.0023333	4	0.023077	6	0.6543333	
4	3	1.49	3	0.538667	2	0.009767	4	0.134933	4	0.530133	2	0.008	4	0.015133	3	0.0025	1	0.023267	4	0.6553333	
5	10	1.49	10	0.54	2	0.0098	3	0.135	4	0.530667	2	0.008517	10	0.0157	5	0.0025667	1	0.0233	4	0.656	
6	4	1.4926667	3	0.54	2	0.010	4	0.136333	3	0.531667	3	0.008633	4	0.016	11	0.0026	3	0.024	4	0.6593	
7	4	1.495	3	0.541	2	0.010	3	0.136667	11	0.532	2	0.008843	3	0.016033	4	0.0029667	1	0.024067	3	0.66	
8	4	1.4956667	4	0.542333	2	0.010033	3	0.138	4	0.532333	2	0.008867	4	0.0165	4	0.003	3	0.0244	10	0.67	
9	7	1.500	4	0.545233	2	0.0103	4	0.139967	11	0.533	2	0.0092	4	0.016667	4	0.0030667	1	0.0244	11	0.671	
10	4	1.500667	4	0.545267	2	0.010333	4	0.1400	7	0.534	2	0.009267	3	0.0169	11	0.0031	1	0.024733	4	0.6756667	
11	4	1.5016667	10	0.546333	2	0.0104	3	0.14	4	0.534267	2	0.0093	4	0.016967	9	0.0031	3	0.024867	11	0.677	
12	14	1.5033333	4	0.54945	2	0.0105	5	0.140333	14	0.534667	2	0.011033	10	0.017	4	0.0032667	3	0.025	4	0.6771667	
13	11	1.5033333	3	0.55	4	0.1424	4	0.1424	4	0.535667	11	0.017					1	0.025	4	0.6801333	
14	4	1.5041	4	0.5501			4	0.142667	3	0.538333	3	0.017					1	0.025333	14	0.6816667	
15	4	1.50559	4	0.550933			3	0.143667	10	0.54	3	0.017					1	0.025467	6	0.6822333	
16	11	1.51	14	0.551333			10	0.145	3	0.54	14	0.017033					1	0.0255	3	0.688	
17	3	1.5133333	11	0.564			10	0.147333	8	0.540667	4	0.017033					11	0.0255	3	0.689	
18	10	1.5133333	4	0.565333			4	0.152	3	0.546	6	0.017067					11	0.025667	3	0.691	
19	8	1.5146667	11	0.565667			4	0.154333	10	0.546	3	0.0173					10	0.027	4	0.6941667	
20	3	1.5166667	3	0.567			4	0.1590	4	0.548667	11	0.0175							10	0.6983333	
21	4	1.5236667							4	0.548667	4	0.0204								4	0.7033333
22	4	1.5240							4	0.551267											
Average		1.501807		0.545466		0.01002		0.140832		0.536415		0.00846		0.016268		0.002650		0.02436		0.675483	
Std Dev		0.000067		0.000071		0.00034		0.000071		0.000067		0.00030		0.000069		0.000097		0.00075		0.000071	
H		0.014		0.0077		0.0011		0.0038		0.0077		0.0010		0.0013		0.00062		0.0016		0.0087	
U ₁		0.014		0.0077		0.0011		0.0038		0.0077		0.0011		0.0013		0.00063		0.0018		0.0087	
t-statistic		2.08		2.09		2.20		2.09		2.08		2.20		2.09		2.20		2.10		2.09	
U ₂		0.028		0.016		0.0025		0.0079		0.016		0.0023		0.0028		0.0014		0.0037		0.018	
U ₃		0.0060		0.0036		0.00072		0.0018		0.0034		0.00067		0.00061		0.00040		0.00086		0.0040	
Certified		1.50		0.55		0.0100		0.141		0.54		0.008		0.016		0.0026		0.024		0.68	
Uncertainty		0.03		0.04		0.0007		0.009		0.02		0.001		0.002		0.0006		0.002		0.03	
Tolerance		0.09		0.12		0.0021		0.027		0.06		0.003		0.006		0.0018		0.006		0.09	

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* Code for method

Certified values listed as weight percent

Analysis	*	Ti	*	V
1	4	0.2663333	5	0.284
2	5	0.2896667	3	0.286667
3	14	0.2903333	10	0.286667
4	11	0.291	3	0.287333
5	4	0.292	11	0.289
6	4	0.292	4	0.289
7	11	0.2923333	11	0.289333
8	4	0.2997333	3	0.289333
9	10	0.30	10	0.29
10	3	0.3013333	3	0.29
11	4	0.30306	14	0.290
12	4	0.3099667	4	0.2900
13	3	0.31	4	0.291333
14	3	0.31	4	0.291467
15	4	0.3111667	4	0.291633
16	4	0.3121667	4	0.293867
17	3	0.3133333	4	0.295967
18	4	0.3153333	3	0.3
19	10	0.3223333	4	0.303
20	3	0.331	4	0.304667
Average		0.302655		0.2912
Std Dev		0.000071		0.0032
H		0.0056		0.0055
U ₁		0.0056		0.0064
t-statistic		2.09		2.09
U ₂		0.012		0.013
U ₃		0.0026		0.0030
Certified		0.30		0.291
Uncertainty		0.04		0.007
Tolerance		0.12		0.021

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* Code for method

Reference values listed as weight percent

Analysis	*	Ca	*	Sb	*	Sn	*	Ta	*	W	*	Zr
1	4	0.0001	5	0.013533	9	0.0082	5	0.013167	4	0.004833	4	0.017333
2	11	0.0002	5	0.013767	4	0.010	5	0.014233	5	0.006043	4	0.018467
3	4	0.0002	4	0.014167	3	0.0107	4	0.014367	5	0.006633	4	0.020133
4	4	0.0002	5	0.0143	4	0.011467	4	0.015	4	0.0069	11	0.0221
5	11	0.0002	4	0.015467	3	0.012	4	0.015733	4	0.007017	11	0.022133
6	3	0.0002333	3	0.015967	4	0.012233	5	0.0166	5	0.007767	4	0.024033
7	5	0.0063	3	0.0177	5	0.0123	3	0.019133	4	0.015667	14	0.026667
8			4	0.020567	5	0.012367	10	0.020233	11	0.021267	4	0.026967
9			4	0.021333	4	0.012467	4	0.025767	4	0.021567	4	0.027067
10			4	0.023267	5	0.012633	4	0.0276	4	0.022967	5	0.027567
11			9	0.023533	10	0.013	14	0.028367	4	0.023033	3	0.029267
12			4	0.026167	4	0.0135			14	0.023033	4	0.029367
13			11	0.0313	4	0.014			3	0.024433	5	0.029467
14					3	0.0140			11	0.026	3	0.0309
15					4	0.0149			3	0.027667	3	0.033
16					4	0.014933			3	0.036		
17					3	0.015						
18					11	0.018067						
19					11	0.0188						
20												
Average		0.0011		0.01911		0.013188		0.019109		0.017552		0.025631
Std Dev		0.0031		0.00074		0.000073		0.000095		0.000079		0.000082
H		0.0004		0.0014		0.0012		0.0014		0.0014		0.0014
U ₁		0.0031		0.0016		0.0012		0.0014		0.0014		0.0014
t-statistic		2.45		2.18		2.10		2.23		2.13		2.14
U ₂		0.0076		0.0035		0.0026		0.0032		0.0030		0.0030
U ₃		0.029		0.0010		0.00059		0.0010		0.00074		0.00077
Reference		<0.05		0.019		0.013		0.019		<0.05		0.026
Uncertainty				0.007		0.003		0.009				0.009
Tolerance				0.018		0.009		0.018				0.025

For each element, in accordance with the requirements of ISO 17034 and Guide 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 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 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	*	Zn																	
1	5	9.6																	
2	5	9.6																	
3	5	9.8																	

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

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
NSL Analytical	Cleveland, OH	ANAB	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Shiva Analyticals Private Limited	Hoskote, Bangalore	NABL	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Luvak Inc.	Boylston, MA	PRI	17025
Laboratory Testing, Inc.	Hatfield, PA	A2LA	17025
Raghavendra Spectro Metallurgical Laboratory	Karnataka, India	NABL	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
APL, Inc	Milwaukee, WI	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: AR 148, 546, 614A, 619D, 644, 645, 659, 668, 872, 878, 882, 886, 895, 948, 960, 1650, 1658; BAS 404/1, 409, 410/2, 458, 460, 464/1; BS CC-23, LF2B, 4, 42, 42A, 61G, 70B, 181, 231, 406, 1144A, 1290, 1762, 1765, 2931, 4130, 4142SE, 4150, 8740; CKD 181A, 244C, 249C; CMSI 2075; ECRM 85-1, 86-1, 87-1; IARM 28D, 209B, 210C, 229; IMZ 51/1, 112, 120, 195; JSM M402-4; JSS GS-1d; LECO 501-503, 502-713, 502-856, 502-870, 502-906, 502-913, 502-916, 502-935, 862-747; NCS NS 11078, NS 11079, NS 20035b; SRM 16F, 160B, 293, 361, 363, 364, 1163, 1262A, 1263A, 1763, 1763A.

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: BS 42, 42A, 231; CMSI 2075; SRM 1163, 1262A, 1263A.

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 1763 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 cast stock for this CRM was produced by SPL-LABMAT s.r.o. Bohumin, Czech Republic.

Form: This CRM is machined in the form of a disc, approximately 37mm in diameter and 20mm 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 upward 10 mm from the larger diameter surface.

Note: Shrinkage cavities may appear in the top portion of some discs. These cavities are normal and will not affect the certified portion of the disc.

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 1763-071323. 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 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 17025:2017 General requirements for the competence of testing and calibration laboratories

ISO Standard 9001:2015 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 35:2017 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 13, 2023.

Beau R. Brammer

President