

Brammer Standard Company, Inc.

Certificate of Analysis

BS 1762

Certified Reference Material for Low Alloy Steel

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.049	0.003		Nb	0.002
As	0.025	0.005		Ni	0.02
B	0.0048	0.0004		O	0.0008
C	0.363	0.004		P	0.002
Co	0.064	0.003		S	0.001
Cr	0.929	0.009		Si	0.01
Cu	0.133	0.004		Sn	0.002
Fe	93.9	0.1		Ti	0.002
Mn	2.04	0.02		V	0.003
Mo	0.347	0.007		W	0.003
N	0.017	0.001			
	Reference Value ¹	Estimate of Uncertainty ²	Reference Values⁴	Reference Value ¹	Estimate of Uncertainty ²
Ca	0.002	0.001		Pb	0.002

Informational Values^{3,5}

Mg (0.0003)

Sb (0.02)

Ta (0.03)

Zn (0.01)

Zr (0.01)

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 Bi, Ce, Cl, Ga, Ge, Hf, Ir, La, Nd, Re, Sr, Te, Th, U, and Y 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	*	Mn	*	Mo	
1	3	0.0441	9	0.0192333	7	0.00406	11	0.355	3	0.055667	4	0.91	4	0.12	16	93.8175	10	1.99251	8	0.32	
2	5	0.044867	11	0.0194	4	0.0044	11	0.357	12	0.057333	11	0.917	4	0.122667	14	93.8333	4	2.00667	3	0.3363	
3	10	0.04518	5	0.0197667	3	0.00450	1	0.359	10	0.0577	8	0.92	4	0.126667	16	93.86	3	2.017	3	0.33788	
4	3	0.0472	4	0.0200667	3	0.004513	1	0.35913	4	0.0595	3	0.921	8	0.129	16	93.86	4	2.020	4	0.34	
5	4	0.047333	3	0.024	14	0.0048	3	0.36	4	0.0627	3	0.922	11	0.13	16	93.87	4	2.02	4	0.341	
6	4	0.047367	4	0.02433	11	0.0048	1	0.36	10	0.063	11	0.927	8	0.131	16	93.8798	3	2.02	3	0.342	
7	4	0.047867	12	0.0253333	11	0.0048	10	0.36067	3	0.0639	11	0.928	10	0.131	3	93.8833	3	2.03	4	0.34393	
8	11	0.048	5	0.0257667	3	0.0049	3	0.3632	3	0.0641	4	0.928667	11	0.132	16	93.89	11	2.04	10	0.34403	
9	11	0.048	4	0.0277	11	0.0049	1	0.36333	14	0.064667	3	0.93	3	0.132	16	93.9	10	2.04	3	0.34467	
10	11	0.0484	4	0.0279333	3	0.00494	3	0.364	8	0.0647	4	0.93	3	0.132667	4	93.93	10	2.04	14	0.346	
11	4	0.048867	10	0.028	4	0.0050	1	0.36467	3	0.065	4	0.9302	4	0.132667	10	93.9367	14	2.04333	10	0.346	
12	3	0.049	3	0.0287	4	0.005033	1	0.365	4	0.065133	3	0.9302	11	0.133	13	94.071	3	2.0459	11	0.348	
13	4	0.049733	3	0.0290	3	0.0051	1	0.3652	4	0.065167	14	0.931333	10	0.134	4	94.2	4	2.047	7	0.348	
14	14	0.049767	5	0.0294667	4	0.0051	1	0.367	11	0.0655	4	0.932933	10	0.13417			4	2.0492	4	0.3495	
15	4	0.050033	3	0.03	4	0.005467	1	0.36757	4	0.065933	4	0.9379	3	0.135			3	2.05	4	0.34957	
16	3	0.052						11	0.368	10	0.06614	10	0.939	3	0.1358			8	2.05333	11	0.35
17	3	0.0560						3	0.368	11	0.0662	4	0.943333	4	0.136067			11	2.06	3	0.35
18	3	0.05675						1	0.37	3	0.067	10	0.946667	4	0.139033			11	2.06	11	0.35
19										11	0.0674			4	0.140133			4	2.06333	4	0.35267
20										4	0.068633			14	0.143333			3	2.06667	10	0.35633
21										3	0.07125							8	2.07	4	0.36233
22																		4	2.09197	3	0.375
Average		0.0489		0.025246		0.00477		0.3628		0.064125		0.929180		0.132510		93.920		2.0415		0.3469	
Std Dev		0.0012		0.000082		0.00014		0.0033		0.000069		0.000075		0.000071		0.031		0.0039		0.0034	
H		0.0022		0.0016		0.00078		0.0062		0.0025		0.010		0.0036		0.19		0.016		0.0060	
U ₁		0.0025		0.0016		0.00080		0.0070		0.0025		0.010		0.0036		0.19		0.017		0.0069	
t-statistic		2.11		2.14		2.14		2.11		2.09		2.11		2.09		2.18		2.08		2.08	
U ₂		0.0054		0.0035		0.0017		0.015		0.0053		0.022		0.0076		0.42		0.035		0.014	
U ₃		0.0013		0.00090		0.00044		0.0035		0.0012		0.0052		0.0017		0.12		0.0074		0.0031	
Certified		0.049		0.025		0.0048		0.363		0.064		0.929		0.133		93.9		2.04		0.347	
Uncertainty		0.003		0.005		0.0004		0.004		0.003		0.009		0.004		0.1		0.02		0.007	
Tolerance		0.009		0.015		0.0017		0.012		0.009		0.027		0.012		0.4		0.06		0.021	

Analysis	*	N	*	Nb	*	Ni	*	O	*	P	*	S	*	Si	*	Sn	*	Ti	*	V
1	2	0.015	10	0.06562	11	1.14	2	0.00581	4	0.0286	3	0.034	4	0.3613	3	0.0760	4	0.09063	3	0.18733
2	2	0.015625	4	0.0678333	14	1.15	2	0.00594	17	0.030	1	0.035167	10	0.3645	4	0.07607	10	0.09157	4	0.18867
3	2	0.015867	11	0.0724	3	1.15	2	0.00597	10	0.0302	1	0.0352	4	0.367	4	0.07687	3	0.092	4	0.19
4	2	0.0164	11	0.0732	11	1.15	2	0.0060	4	0.0305	1	0.035633	10	0.368333	5	0.07693	3	0.09213	3	0.190
5	3	0.01656	11	0.0732	4	1.153333	2	0.0061	7	0.030933	1	0.0358	9	0.369333	10	0.077	3	0.09419	14	0.19
6	2	0.0167	4	0.0739333	3	1.156667	2	0.0064	4	0.031033	1	0.036	14	0.37	4	0.07737	4	0.09537	4	0.1901
7	2	0.016933	3	0.074	4	1.157	2	0.00683	11	0.0312	1	0.036567	6	0.370133	11	0.0778	11	0.0954	10	0.19333
8	2	0.017	14	0.074	11	1.16	2	0.00782	3	0.0314	3	0.03675	4	0.370167	3	0.078	4	0.0954	4	0.1934
9	2	0.017133	10	0.0741	4	1.1600			11	0.0316	11	0.037	6	0.373	3	0.078	11	0.0954	11	0.194
10	2	0.0172	4	0.0741	17	1.16			10	0.0316	11	0.0371	3	0.375333	14	0.07907	4	0.09597	10	0.194
11	2	0.018067	4	0.0742333	3	1.1606			4	0.032033	1	0.03720	4	0.376	11	0.0791	14	0.09597	3	0.194
12	2	0.0194	4	0.0744667	4	1.161			4	0.032033	3	0.0373	11	0.377	4	0.0791	3	0.096	3	0.1942
13			3	0.0756	4	1.162667			14	0.032133	1	0.0373	11	0.378	4	0.07927	4	0.096	3	0.195
14			3	0.076	8	1.163667			11	0.0324	11	0.0375	10	0.38	4	0.08037	4	0.09657	11	0.195
15			4	0.0768333	10	1.165			3	0.033	1	0.0377	3	0.381	3	0.0804	11	0.0973	11	0.195
16			3	0.0788	4	1.1731			4	0.033267	1	0.038233	11	0.384	11	0.081	10	0.098	4	0.196
17			3	0.08475	3	1.180			3	0.034	10	0.039	3	0.3864	10	0.0821	3	0.098		
18					3	1.1875			3	0.034	1	0.0397	3	0.39	3	0.0825	10	0.10167		
19					4	1.2			3	0.0341	1	0.039917	4	0.395667			3	0.104		
20					10	1.20			3	0.0355			4	0.40						
21													3	0.415						
Average		0.01726		0.0742		1.1606		0.00637		0.03212		0.0375		0.3780		0.0790		0.0961		0.1930
Std Dev		0.00066		0.0017		0.0047		0.00027		0.00094		0.0011		0.0036		0.0018		0.0020		0.0032
H		0.0014		0.0027		0.012		0.00089		0.0018		0.0020		0.0063		0.0028		0.0031		0.0044
U ₁		0.0015		0.0032		0.013		0.00092		0.0020		0.0022		0.0072		0.0033		0.0037		0.0054
t-statistic		2.20		2.12		2.09		2.36		2.09		2.10		2.09		2.11		2.10		2.13
U ₂		0.0033		0.0068		0.027		0.0022		0.0043		0.0047		0.015		0.0070		0.0077		0.012
U ₃		0.0010		0.0017		0.0059		0.00077		0.0010		0.0011		0.0033		0.0017		0.0018		0.0029
Certified		0.017		0.074		1.16		0.0064		0.032		0.037		0.38		0.079		0.096		0.193
Uncertainty		0.001		0.002		0.02		0.0008		0.002		0.001		0.01		0.002		0.002		0.003
Tolerance		0.003		0.007		0.06		0.0022		0.006		0.005		0.03		0.007		0.008		0.012

BS 1762

* Code for method

Certified values listed as weight percent

Analysis	*	W
1	3	0.0252
2	11	0.0253
3	4	0.025933
4	11	0.0262
5	3	0.027
6	10	0.027
7	3	0.027
8	10	0.02725
9	4	0.028333
10	5	0.0284
11	4	0.030967
12	14	0.031467
13	4	0.0319
14	4	0.032367
15	11	0.0343
16	3	0.0355
Average		0.029007
Std Dev		0.000079
H		0.0017
U ₁		0.0017
t-statistic		2.13
U ₂		0.0037
U ₃		0.00093
Certified		0.029
Uncertainty		0.003
Tolerance		0.009

BS 1762

* Code for method

Reference values listed as weight percent

Analysis	*	Ca	*	Pb
1	3	0.00059	11	0.0075
2	11	0.0015	11	0.0075
3	12	0.001733	11	0.0081
4	11	0.0018	5	0.0087333
5	14	0.001933	9	0.0087667
6	4	0.0020	4	0.0089667
7	4	0.002333	10	0.010
8	3	0.00283	3	0.010
9	4	0.003133	5	0.0124333
10	3	0.0032	3	0.0128
11	11	0.0032	4	0.0128333
12			3	0.013
13			5	0.0132333
14			12	0.0133333
15			3	0.0141
Average		0.002120		0.010753
Std Dev		0.000067		0.000082
H		0.00057		0.0011
U ₁		0.00057		0.0011
t-statistic		2.23		2.14
U ₂		0.0013		0.0024
U ₃		0.00038		0.00062
Reference		0.002		0.011
Uncertainty		0.001		0.002
Tolerance		0.002		0.006

Analysis	*	Mg	*	Sb	*	Ta	*	Zn	*	Zr
1	12	0.000102	11	0.0148	12	0.0190	5	0.00533	12	0.0068
2	3	0.00024	11	0.0153	3	0.0196	14	0.00673	4	0.007733
3	4	0.0003	11	0.0179	10	0.020	5	0.00682	4	0.010333
4	4	0.000333	4	0.0194667	5	0.021633	4	0.00763	3	0.0104
5	3	0.00041	14	0.0195667	4	0.0218	3	0.0090	5	0.010567
6			4	0.0201333	4	0.0226	3	0.0090	4	0.010767
7			5	0.0257333	10	0.022733	12	0.00943	5	0.0108
8			3	0.026	4	0.0247			3	0.011
9			4	0.0277667	5	0.025667			3	0.012
10			12	0.0283333	3	0.027			10	0.012
11			5	0.0303	3	0.03			4	0.013833
12			3	0.0310	11	0.0523			3	0.0139
13			5	0.0311333	11	0.0568			14	0.014
14			4	0.0312333	4	0.0601			4	0.0144
15					11	0.0602			11	0.0144
16					14	0.060433			11	0.0156
17									11	0.0156
Average		0.00028		0.02		0.03		0.008		0.012
Std Dev		0.00026		0.15		0.19		0.062		0.067
H		0.00027		0.0015		0.0018		0.00098		0.001
U ₁		0.00037		0.15		0.19		0.062		0.067
t-statistic		2.78		2.16		2.13		2.45		2.12
U ₂		0.0010		0.33		0.41		0.15		0.14
U ₃		0.00046		0.088		0.10		0.058		0.035
Infomational		(0.0003)		(0.02)		(0.03)		(0.01)		(0.01)

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 it's 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.

Analysis	*	Bi	*	Ce	*	Cl	*	Ga	*	Ge	*	Hf	*	Ir	*	La	*	Nd	*	Re
1	12	130	12	0.05	12	0.01	12	6.2	12	7.5	12	0.47	12	0.02	12	0.02	12	0.02	12	0.21
2	12	140	12	0.08			12	6.7	12	7.7	12	0.66			12	0.02			12	0.24
3	3	169	12	0.12			12	7.2	12	7.8	12	0.87			12	0.03			12	0.34
4	12	190																		
Analysis	*	Sr	*	Te	*	Th	*	U	*	Y										
1	12	0.14	12	170	12	0.01	12	0.05	12	0.03										
2	12	0.14	12	170	12	0.02	12	0.07	12	0.03										
3	12	0.22	12	210	12	0.03	12	0.11	12	0.04										

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	17 Wet
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
Dirats Laboratories	Westfield, MA	ANAB	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Vitkovic	Ostrava	ILAC	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
Enviform	Stare Mesto, Trinec	ILAC	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Luvak Inc.	Boylston, MA	PRI	17025
Chicago Spectro	Chicago, IL	A2LA	17025

A2LA = American Association for Laboratory Accreditation
 ANAB = ANSI-ASQ National Accreditation Board
 CNAS = China National Accreditation Service
 ILAC = International Laboratory Accreditation Organization
 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 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: 11XC4, 12X15255, 12X15260, 12X15266, 12X353, 12X356, 12X43400; AR 644, 654, 668, 673, 882, 886, 889, 892, 946, 1648, 1651, 1652, 1653; BAS 423, 451, 464/1; BS LF2B, 40B, 54H, 67B, 3972, 8620C; CKD DS2, 167A, 169A, 181A, 183A, 186A, 187A, 189A, 210S, 211S, 217A, 221A, 222A, 223A, 235, 236, 248, 249; ECRM 096-1, 479-1, 480-1; IMZ 114A; IPT 43, 45, 75A; JSS 168-7, 517-3; LECO 501-024, 501-644, 501-645, 501-676, 502-198, 502-255, 502-416, 502-712, 502-894, 502-916, 502-928; SRM 7G, 8F, 16D, 16E, 82, 134A, 153A, 160B, 361, 362, 363, 364, 391, 393, 1162, 1168, 1262A, 1263, 1269, 1762, 3109A, 3131A, 3168A.

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 — BAS 410/2, 483; BS 40B, 67B, 3972; CKD 181A; DSZU CA013; ECRM 184-1; JSS 517-3; LECO 502-869; SRM 1162, 1262A, 1762, NCS NS 11037.

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 1762 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; Bohumin, Czech Republic.

Form: This CRM is machined in the form of a disc, approximately 37 mm in diameter and 25 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 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 1762-040820. 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 17025:2005 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 35:2006 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 April 8, 2020.

Beau R. Brammer
President