Brammer Standard Company, Inc.

Certificate of Analysis

BS 70C

Certified Reference Material for Leaded Steel Grade 41L40 MOD

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.019**	0.002	**N**	**0.0079**	0.0005
As	**0.007**	0.001	**Ni**	**0.247**	0.006
C	**0.387**	0.008	**O**	**0.0020**	0.0006
Co	**0.0086**	0.0008	**Pb**	**0.133**	0.008
Cr	**0.99**	0.04	**S**	**0.020**	0.002
Cu	**0.123**	0.006	**Si**	**0.27**	0.01
Fe	**96.7**	0.3	**Sn**	**0.008**	0.001
Mn	**0.90**	0.02	**Ti**	**0.0020**	0.0004
Mo	**0.202**	0.008	**V**	**0.0026**	0.0005

Reference Values[3,4]

	Reference Value[1]	Estimate of Uncertainty[2]		Reference Value[1]	Estimate of Uncertainty[2]
Mg	**<0.005**		**P**	**0.009**	0.002
Nb	**<0.005**		**Zr**	**<0.005**	

Informational Values[3,5]

B (0.0003) Sb (0.003) W (0.0006)

[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, Ca, Ce, Ga, Ge, Ir, La, Re, Ta, and 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.

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BS 70C * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N
1	12	0.0140	9	0.00586667	1	0.37129	4	0.0075	4	0.929	10	0.115	13	96.324	4	0.837	4	0.191	2	0.00677
2	4	0.0146	3	0.0059	1	0.3763333	3	0.0078	10	0.96	4	0.115	3	96.463333	4	0.8856667	4	0.1959333	2	0.00759
3	4	0.0165	12	0.0060	1	0.379	5	0.00807333	10	0.965	10	0.12	16	[96.5175]	4	0.887	3	0.196	2	0.00766
4	4	0.0171	5	0.0061	10	0.3795	4	0.00812	3	0.9666667	4	0.1201333	16	[96.6]	7	0.8896667	4	0.1962867	2	0.00777
5	5	0.0175333	3	0.0066	1	0.3796667	4	0.00813333	4	0.9696667	5	0.1203333	4	96.613333	10	0.890	17	0.197	2	0.00777
6	4	0.0177667	5	0.00676667	1	0.3836333	10	0.0083	14	0.97	4	0.123	16	[96.667]	8	0.89	5	0.198	2	0.00777
7	5	0.0178	5	0.00755333	1	0.386	3	0.00836667	4	0.9701667	4	0.123	14	96.666667	4	0.8912567	4	0.1995333	2	0.00787
8	3	0.0180	4	0.00756667	3	0.386	10	0.0086	4	0.9703	10	0.123	10	96.68	4	0.8913333	3	0.2	2	0.00793
9	4	0.01826	4	0.00781667	1	0.3863333	4	0.00863333	4	0.9843333	14	0.1236667	16	[96.7008]	3	0.8916667	4	0.2006667	2	0.00797
10	3	0.019	15	0.00782667	1	0.389	5	0.00863333	8	0.99	3	0.1236667	16	[96.7533]	10	0.895	14	0.2013333	2	0.00816
11	4	0.0195667	4	0.00796667	1	0.391	5	0.00866667	3	0.994	8	0.124	16	[96.81]	4	0.8959333	4	0.202	2	0.0082
12	14	0.0195667	5	0.00836667	1	0.394	8	0.00885667	18	1.00	4	0.124	4	97.08	3	0.8973333	10	0.203	2	0.00823
13	3	0.019975			3	0.3955	4	0.00916667	4	1.0005333	3	0.1243333			4	0.8997	4	0.2036667	2	0.0087
14	3	0.0205			1	0.3973333	4	0.00916667	4	1.0018	4	0.12451			10	0.900	10	0.2036667		
15	4	0.0207			1	0.4113333	3	0.0092	4	1.01	4	0.1265			4	0.902	4	0.205		
16	4	0.0226333			1	0.4195	14	0.0093	4	1.0135	8	0.127			4	0.902	3	0.20675		
17	10	0.0229					3	0.009725	3	1.02	3	0.12825			14	0.9026667	3	0.207		
18									10	1.0233333	4	0.1283333			8	0.9026667	8	0.21		
19											7	0.1303333			3	0.904	10	0.212		
20															4	0.9095	4	0.2183333		
21															17	0.9100				
22															18	0.915				
23															3	0.9705				
Average		0.01855		0.00730		0.3866		0.008602		0.985461		0.123372		96.671		0.8982		0.202359		0.00787
Std Dev		0.00063		0.00027		0.0041		0.000077		0.000075		0.000073		0.032		0.0056		0.000071		0.00025
H		0.0011		0.00071		0.0055		0.00075597		0.010		0.0028		0.42		0.009		0.0037		0.00073
U_1		0.0012		0.00076		0.0069		0.00076		0.010		0.0028		0.42		0.011		0.0037		0.00077
t-statistic		2.12		2.20		2.13		2.12		2.11		2.10		2.20		2.07		2.09		2.18
U_2		0.0026		0.0017		0.015		0.0016		0.021		0.0058		0.93		0.023		0.0077		0.0017
U_3		0.00063		0.00048		0.0037		0.00039		0.0050		0.0013		0.27		0.0048		0.0017		0.00047
Certified		**0.019**		**0.007**		**0.387**		**0.0086**		**0.99**		**0.123**		**96.7**		**0.90**		**0.202**		**0.0079**
Uncertainty		0.002		0.001		0.008		0.0008		0.04		0.006		0.3		0.02		0.008		0.0005
Tolerance		0.006		0.003		0.024		0.0024		0.12		0.018		0.9		0.06		0.024		0.0017

Analysis	*	Ni	*	O	*	Pb	*	S	*	Si	*	Sn	*	Ti	*	V
1	3	0.24	2	0.00143333	3	0.122	1	0.016975	4	0.253	10	0.0062	4	0.0014	12	0.0015
2	4	0.2414867	2	0.00144333	5	0.1236667	3	0.017225	3	0.2583333	12	0.0066	10	0.0016	4	0.0019333
3	18	0.242	2	0.00153667	4	0.1256667	12	0.01733333	3	0.26	3	0.0066	3	0.0019333	4	0.0021
4	4	0.24225	2	0.0016	4	0.128	1	0.0176	18	0.26	5	0.0072667	5	0.0019333	4	0.0022
5	4	0.2424333	2	0.00173333	3	0.1286667	1	0.01846667	4	0.2623333	5	0.0073667	4	0.0019667	5	0.0022333
6	4	0.2446667	2	0.001764	4	0.1300	10	0.0186	4	0.263	5	0.0075	5	0.0021	4	0.0024333
7	3	0.246	2	0.00193333	8	0.13	3	0.01866667	4	0.2642333	9	0.0076	4	0.0021333	4	0.00246
8	4	0.2463333	2	0.002	17	0.132	1	0.01893333	4	0.2678933	4	0.0076	4	0.0021867	5	0.0025
9	10	0.247	2	0.00211	10	0.133	1	0.01913333	10	0.268	10	0.0083	4	0.0023333	5	0.0027567
10	8	0.2473333	2	0.0025	4	0.133	1	0.01966667	4	0.2701	4	0.0085333	14	0.0023667	3	0.002775
11	3	0.2496667	2	0.00278333	3	0.134	1	0.01983333	4	0.2702	5	0.00899	5	0.00239	10	0.0030
12	4	0.25	2	0.00282	14	0.134	1	0.01996667	3	0.271	9	0.0092667	3	0.002525	4	0.0036667
13	10	0.250	2	0.0029	10	0.135	1	0.02	14	0.2726667	3	0.009325			14	0.0038
14	10	0.250			4	0.1351667	1	0.0211	4	0.273	3	0.0098333				
15	4	0.2501			4	0.1400667	1	0.0215	3	0.2835	4	0.0101667				
16	3	0.2505			3	0.141	1	0.02256667	10	0.2865						
17	4	0.2507333			4	0.1425	10	0.0228	5	0.2933333						
18					4	0.1446667	1	0.02343333	4	0.294						
Average		0.2472		0.00196		0.132911		0.019656		0.2701		0.008077		0.002010		0.002566
Std Dev		0.0041		0.00010		0.000075		0.000075		0.0039		0.000082		0.000090		0.000088
H		0.0042		0.00044		0.0029		0.0011		0.0044		0.00074		0.0004409		0.00048
U_1		0.0058		0.00045		0.0029		0.0011		0.0058		0.00074		0.00045		0.00049
t-statistic		2.12		2.18		2.11		2.11		2.11		2.14		2.20		2.18
U_2		0.012		0.0010		0.0061		0.0023		0.012		0.0016		0.00099		0.0011
U_3		0.0030		0.00027		0.0014		0.00054		0.0029		0.00041		0.00029		0.00029
Certified		**0.247**		**0.0020**		**0.133**		**0.020**		**0.27**		**0.008**		**0.0020**		**0.0026**
Uncertainty		0.006		0.0006		0.008		0.002		0.01		0.001		0.0004		0.0005
Tolerance		0.018		0.0018		0.024		0.006		0.03		0.003		0.0012		0.0015

BS 70C * Code for method Reference values listed as weight percent

Analysis	*	Mg	*	Nb	*	P	*	Zr
1	12	0.000021	12	0.0000523	5	0.0057667	5	0.00001
2	3	0.00013	5	0.0000667	12	0.0062	12	0.0000267
3	4	0.0002	4	0.00016467	10	0.0062667	4	0.00093333
4	4	0.0010433	5	0.00026667	3	0.0075	10	0.00123333
5			3	0.0013	4	0.00766	3	0.00155
6			14	0.00216667	4	0.0081667	10	0.0019
7			3	0.00293333	7	0.0081933	4	0.00192667
8			4	0.00343333	3	0.0082333		
9					10	0.0084		
10					18	0.009		
11					4	0.0090333		
12					3	0.009275		
13					4	0.0094		
14					3	0.010		
15					4	0.0101		
16					4	0.0108667		
17					10	0.011		
18					4	0.0112		
19					14	0.0116		
Average						0.00870		
Std Dev						0.00036		
H						0.00076		
U_1						0.00084		
t-statistic						2.10		
U_2						0.0018		
U_3						0.00040		
Reference		**<0.005**		**<0.005**		**0.009**		**<0.005**
Uncertainty						0.002		
Tolerance						0.006		

BS 70C * Code for method Informational values listed as weight percent

Analysis	*	B	*	Sb	*	W
1	4	0.0001	12	0.00236667	12	0.00048
2	12	0.0001233	5	0.00266667	5	0.0008033
3	5	0.0002				
4	7	0.0002				
5	3	0.0003667				
6	3	0.0004				
7	4	0.0004333				
Average		0.00026		0.003		0.0006
Std Dev		0.00019		0.024		0.0023
H		0.00025		0.001		0.0003
U_1		0.00032		0.024		0.0023
t-statistic		2.45		12.71		12.71
U_2		0.00078		0.31		0.029
U_3		0.00029		0.22		0.021
Informational		(0.0003)		(0.003)		(0.0006)

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. 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 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 70C * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Bi	*	Ca	*	Ce	*	Ga	*	Ge	*	Ir	*	La	*	Re	*	Ta	*	Zn
1	12	0.05	12	0.07	12	0.03	12	9.1	12	13	12	0.01	12	0.02	12	0.02	5	0.90	12	6.2
2	12	0.05	12	0.07	12	0.03	12	9.3	12	13			12	0.02	12	0.02	5	6.8	12	6.2
3	12	0.05	12	0.09	12	0.03	12	9.5	12	14			12	0.02	12	0.02	5	11	12	6.3
4																			5	7.1
5																			5	7.5
6																			5	12

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	AAS
6	Gravimetric	12	GD Mass Spectrometry	18	Wet

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

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
Jones & Laughlin Steel Corporation	Aliquippa, PA		
Evans Analytical Group	Liverpool, NY	A2LA	17025
Exova	Glendale Heights, Il	A2LA	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Analytical Process Laboratories	Milwaukee, WI	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
Vitkovice Testing Center	Ostrava, Czech	ILAC	17025
Element Materials Technology	Huntington Beach, CA	A2LA	17025
TUV Rheinland	Bangalore, India	NABL	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	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: 13X125370, 23X80030; AR 612B, 614A, 644, 645, 654, 657, 659, 662, 668, 676, 870, 882, 884, 889, 1650, 1652, 1653; BAM 039-2; BAS 4-88, 261, 342, 346A, 406/2, 409, 410/2, 455/1, 461, 464/1; BS 45B, 70A, 70B, 71A, 72B, 80F, 81G, 85D, 181, 406, 1026, 1290, 1765, 1962, 2931, 4130, 4142SE, 4150; CKD 244C, 249C; ECRM 085-1, 096-1, 097-1, 184-1, 194-1, 195-1, 286; IARM 30G, 38A, 156A, 182B, 305A; IMZ 123; IPT 12A, 17A, 41A; JK 37; JSS 369-8, 501-3, 514-3, 652-5, 654-5; LECO 501-505, 501-644, 501-646, 501-676, 501-991, 502-328, 502-414, 502-698, 502-712, 502-855, 502-856, 502-873, 502-903, 502-916; SRM 33C, 55D, 125B, 153, 160B, 293, 344, 361, 362, 363, 364, 1155, 1265A; Y41340B.

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: BAM 039-2; BAS 4-88, 409, 410/2, 455/1; BS 70A, 70B, 71A, 72B, 1962; ECRM 085-1, 096-1, 097-1, 286; IPT 41A; JSS 501-3, 514-3; LECO 501-676, 501-991, 502-873; SRM 125B, 293, 361, 362, 363, 364, 1265A; Y41340B.

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 70C 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 bar stock for this CRM was produced by Teledyne Osco Steel; Cleveland, OH.

Form: This CRM is machined in the form of a disc, approximately 41mm in diameter and 19mm 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 70C-021121. 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) 440-9396Web: 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 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 February 11, 2021.

Beau R. Brammer

President