

Brammer Standard Company, Inc.

Certificate of Analysis

BS 3972

Low Alloy Steel Reference Material

	Certified Value ¹	Estimate of Uncertainty ²		Certified Value ¹	Estimate of Uncertainty ²
Analysis listed as percent by weight					
C	0.195	0.003	Co	0.010	0.001
Mn	1.30	0.015	N ⁴	0.0065	0.0003 ⁵
P	0.083	0.002	O	0.0038	0.0005
S	0.056	0.002	Sn	0.012	0.001
Si	0.106	0.004	Ti	0.163	0.006
Cu	0.082	0.003	V	0.191	0.004
Ni	1.19	0.01			
Cr	0.108	0.004		Informational values ³	
Mo	0.032	0.002	Nb	(0.001)	
Al	0.031	0.002	W	(<0.008)	
As	0.012	0.001			
B	0.0104	0.0004			

¹ The certified value listed is the present best estimate of the true value based on the results of an interlaboratory testing program.

² The uncertainties listed are based on value judgments of the material inhomogeneity and the 95% confidence interval. The half-width confidence interval C(95%) is shown on page 2.

³ Data in parentheses are not certified and are provided for information only.

⁴ See caution note on page 5 about the use of optical emission spectrometry for nitrogen analysis.

⁵ The uncertainty value for nitrogen was editorially corrected from 0.003 to 0.0003 on March 6, 2002.

See reverse side for more information.

Certificate Number 3972-022399p1

Analysis	*	C	* Mn	* P	* S	* Si	* Cu	* Ni	* Cr	* Mo
1	7	0.189	33 1.28	14 0.0800	7 0.0524	24 0.0974	4 0.0733	4 1.17	1 0.096	1 0.029
2	7	0.190	1 1.28	1 0.0814	7 0.0526	1 0.100	1 0.076	2 1.174	1 0.104	1 0.030
3	7	0.1919	4 1.2831	34 0.0820	7 0.0539	2 0.102	2 0.0785	1 1.18	2 0.105	1 0.030
4	7	0.193	1 1.29	2 0.082	7 0.0548	1 0.104	2 0.080	1 1.182	20 0.106	1 0.0305
5	7	0.194	2 1.292	2 0.0822	7 0.055	2 0.106	1 0.0820	2 1.182	1 0.106	1 0.0307
6	7	0.195	4 1.30	1 0.0836	43 0.056	35 0.107	1 0.0839	2 1.19	1 0.108	1 0.0308
7	7	0.196	1 1.30	2 0.0842	7 0.056	1 0.108	1 0.084	4 1.192	1 0.109	2 0.0326
8	7	0.197	2 1.300	1 0.0846	7 0.0565	1 0.109	1 0.084	1 1.20	4 0.11	1 0.0330
9	7	0.1971	2 1.31	1 0.085	7 0.0565	4 0.109	2 0.0842	18 1.20	19 0.110	2 0.033
10	7	0.198	1 1.31	2 0.0854	7 0.0568	4 0.109	37 0.085	1 1.20	1 0.110	38 0.0334
11	7	0.198	30 1.31	1 0.086	7 0.0568	2 0.11	28 0.0856	2 1.206	2 0.110	4 0.03498
12	7	0.198	2 1.32		7 0.059	2 0.111	1 0.0856	1 1.21	2 0.111	
13	7	0.1984			7 0.060		2 0.086		2 0.113	
14	7	0.1997								
Average		0.1954	1.298	0.0833	0.0559	0.1060	0.0822	1.191	0.1075	0.0316
Std Dev		0.0033	0.013	0.0019	0.0022	0.0043	0.0040	0.013	0.0043	0.0018
Certified		0.195	1.30	0.083	0.056	0.106	0.082	1.19	0.108	0.032
t		2.1604	2.201	2.2281	2.1788	2.201	2.1788	2.201	2.1788	2.2281
C (95%)		0.0019	0.008	0.0013	0.0013	0.0027	0.0024	0.008	0.0026	0.0012

Analysis	*	Al	* As	* B	* Co	* N	* O
1	4	0.0233	2 0.0104	1 0.0098	1 0.006	11 0.0060	11 0.0030
2	1	0.0287	2 0.0107	2 0.0098	4 0.0081	11 0.0060	11 0.0032
3	1	0.030	2 0.0109	1 0.0099	12 0.0091	11 0.0063	11 0.0034
4	1	0.030	5 0.0112	21 0.0104	1 0.0096	11 0.0064	11 0.0035
5	1	0.030	2 0.0112	3 0.0104	2 0.0096	11 0.0064	11 0.0036
6	2	0.0311	1 0.0113	2 0.01043	1 0.010	40 0.0064	11 0.0037
7	1	0.0313	25 0.0114	2 0.0105	1 0.010	11 0.0065	11 0.0038
8	2	0.0318	5 0.0118	3 0.0105	1 0.0100	11 0.0066	11 0.0040
9	2	0.0321	1 0.013	21 0.0105	0.010	11 0.00682	11 0.0040
10	29	0.0322	1 0.013	1 0.0110	1 0.0101	11 0.0069	11 0.0046
11	1	0.0325	1 0.0140	2 0.0111	2 0.0102	11 0.00694	11 0.0047
12	16	0.0326		1 0.0111	1 0.0105		
13	2	0.0336			2 0.0111		
Average		0.0307	0.0117	0.01045	0.0096	0.00648	0.00377
Std Dev		0.0026	0.0011	0.00046	0.0013	0.00032	0.00053
Certified		0.031	0.012	0.0104	0.010	0.0065	0.0038
t		2.1788	2.2281	2.201	2.1788	2.2281	2.2281
C (95%)		0.0016	0.0008	0.0003	0.0008	0.00022	0.00036

Analysis	*	Nb	* Sn	* Ti	* V	* W
1	2	0.0002	8 0.009	1 0.154	2 0.183	1 <0.0005
2	1	0.0002	2 0.0107	1 0.154	1 0.188	2 <0.001
3	1	0.0002	1 0.0115	1 0.159	1 0.188	1 <0.002
4	1	0.0007	1 0.0117	1 0.160	1 0.189	39 <0.005
5	1	0.0010	5 0.0120	1 0.160	2 0.1891	1 <0.008
6	2	0.0011	1 0.012	17 0.160	1 0.191	1 0.001
7	2	0.003	1 0.012	2 0.1613	2 0.1912	1 0.001
8	2	0.0034	9 0.0121	2 0.1625	1 0.192	2 0.0029
9			2 0.0122	1 0.164	2 0.192	1 0.003
10			2 0.0124	2 0.167	1 0.193	1 0.005
11			2 0.0124	1 0.168	27 0.194	
12			13 0.0132	2 0.171	1 0.200	
13				4 0.1814	4	
Average		0.0012	0.0118	0.1632	0.1909	
Std Dev		0.0013	0.0011	0.0074	0.0041	
Certified		(0.001)	0.012	0.163	0.191	(<0.008)
t		2.3646	2.201	2.1788	2.201	
C (95%)		0.0011	0.0007	0.0045	0.0026	

* see page 3 for methods of analysis

Data in parentheses are not certified but provided for information only.
Data listed as mass fraction expressed as percent.

$C(95\%) = (t \times sd) / \sqrt{n}$ The half-width confidence interval, where t is the appropriate Student's t value, sd is the interlaboratory standard deviation, and n is the number of acceptable mean values. For further information regarding the confidence interval for the certified value see ISO Guide 35:1989 section 4.

Methods of analysis:**Certificate Number 3972-022399p3**

*Method	Description
1	AES - Inductively Coupled Plasma
2	AES - Optical Emission
3	AES - Inductively Coupled Plasma after solvent extraction
4	Atomic Absorption Spectrometry
5	Atomic Absorption Spectrometry with hydride generation
7	C, S Combustion-Infrared Absorption (ASTM E 1019)
8	Graphite Furnace Atomic Absorption Spectrometry
9	Graphite Furnace Atomic Absorption Spectrometry after three-phase extraction
11	N, O Inert gas Fusion Method (ASTM E 1019)
12	Co MAS - 5-Cl-PADAB spectrophotometric
13	Sn MAS - Benzol extraction phenylfluorone photometric
14	P MAS - Bismuth-phosphorus-molybdenum blue photometric
16	Al MAS - Chromazurol S photometric after separation with cupferron
17	Ti MAS - Diantipyrylmethane photometric after trichlormethane extraction
18	Ni MAS - Dimethylglyoxime photometric
19	Cr MAS - Diphenyl carbazide
20	Cr MAS - Diphenyl carbazide photometric after separation with Na ₂ CO ₃
21	B MAS - Distillation separation-curcumin photometric
24	Si MAS - Molybdenum blue photometric method (ASTM E350)
25	As MAS - Molybdenum blue photometric after separation by distillation
27	V MAS - N-benzoyl phenylhydroxylamine-trichloromethane extraction photometric
28	Cu MAS - Neocuprone-trichloromethane extraction photometric
29	Al MAS - Nitrated Eriochromcyanine-R
30	Mn MAS - Periodate
33	Mn MAS - Potassium periodate oxidation photometric
34	P MAS - P-V-Mo, blue
35	Si MAS - SiVMo
37	Cu MAS - Tetraethylthiuram disulphide
38	Mo MAS - Thiocyanate after extraction with butyl acetate
39	W MAS - Trichloromethane extraction chlorpromazine hydrochloride photometric
40	N Neutralization titrimetric with distillation separation
43	S Precipitation as barium sulphate gravimetric method

AES = Atomic Emission Spectrometry

MAS = Molecular Absorption Spectrometry (photometric, spectrophotometric methods)

Supplemental Data: A nationally known Proficiency Testing Program, with 83 laboratories participating, produced the following data.

	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al
Average	0.1935	1.3031	0.0854	0.0574	0.1082	0.0849	1.1865	0.1091	0.0327	0.0330
Std Dev	0.0071	0.0208	0.0057	0.0050	0.0063	0.0035	0.0332	0.0047	0.0036	0.0024
	N	O	Nb	Sn	Ti	V				
Average	0.0066	0.0037	0.0027	0.0120	0.1643	0.1941				
Std Dev	0.0005	0.0010	0.0016	0.0009	0.0102	0.0063				

Certification Process: The requirements of ISO Guide 31, ISO Guide 34, ISO Guide 35, and ASTM Standard Guides E 1724 and E 1831 were followed for the preparation of this reference material and certificate of analysis. This is a reference material as defined by ISO Guide 30.

Analysis: Chemical analyses were made on chips prepared by a lathe from the certified portion of the bars in accordance with ASTM Standard Practice E 1806. The laboratories participating in the testing normally followed the requirements of ISO Guide 25. The individual values listed on page 2 are the average of each analyst's results. Methods of analysis used were a combination of ASTM Standard Test Methods E 350 and E 1019 plus additional ICP and AA spectrometric methods.

Co-operating Laboratories: The co-operating laboratories were:

Laboratory

ANAREM, Prague, Czech Republic
 Armco Inc., Research & Development, Middletown, Ohio
 Brammer Standard Co., Inc., Houston, Texas
 China National Analysis Center for Iron and Steel, Beijing, China
 J. Dirats and Co., Inc., Westfield, Massachusetts
 LECO Corporation, St. Joseph, Michigan
 Shiva Technologies, Inc., Syracuse, New York
 Shiva Analyticals (India) Ltd., Hoskote, Bangalore, India
 The Timken Company, Canton, Ohio
 VHG Laboratories, Inc., Manchester, New Hampshire

Laboratory contact

Karel Bičovský
 Howard P. Vail
 Richard Beaumont
 Prof. Wang Haizhou
 Eric E. Dirats
 Dennis Lawrenz
 Don Shuman
 Dr. T. V. Ramakrishna
 Douglas Gapen
 Julie M. McIntosh

Homogeneity: This Reference Material was tested for homogeneity using ASTM Standard Practice E 826 and found acceptable.

Traceability: This Reference Material was also examined by optical emission spectrometry using ASTM Standard Test Method E 415 and found to be compatible with the following Certified Reference Materials: NIST SRM C1173, 1261a through 1265a, 1761 through 1767; ECRM 186-1, 191-1; SS 457/1, 458/1; JSS 169-4, 170-6, 171-4. The following Certified Reference Materials were used to validate the analytical data listed on page 2: NIST SRM 13g, 16f, 73c, 885 ; CKD 180A through 187A.

Certificate Number 3972-022399p4

Available Form: This Reference Material is available in the form of a block, approximately 35 mm x 35 mm and 19 mm thick.

Source: This material was produced by the Bethlehem Steel Corporation Homer Research Laboratories. The material was made in a vacuum induction melting furnace and cast into ingots. The bar stock was hot rolled and heat treated.

Use: This Reference Material is intended for use in optical emission and x-ray spectrometric methods of analysis. The entire depth of the block may be used.

Caution: As with any bar material, avoid optical emission spectrometric burns in the center of the block (5 mm radius), as some segregation may be present. The formation of titanium carbide causes a higher nitrogen response using optical emission spectrometry.

Sample Preparation: For best analytical results, use the same method for preparing the analytical surface on all reference materials as you use for production specimens. Avoid overheating the disc during surface preparation.

Safety Notice: A Material Safety Data Sheet (MSDS) 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
Fax: (281) 440-4432

Certified by: _____ on February 23, 1999.
G. R. Brammer

Certificate Number 3972-022399p5

By Certificate Number R-021, the Quality System of Brammer Standard Company, Inc., is registered to ISO 9002 by the American Association for Laboratory Accreditation (A2LA).

**Brammer Standard Company's Chemical Laboratory is accredited to ISO Guide 25 by A2LA.
(Certificate Number 656.01)**

References:

*ASTM documents available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959,
Telephone: 610-832-9500 Fax: 610-832-9555 e-mail: service@astm.org Website: www.astm.org*

E 350 - 90 Standard Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

E 826 - 85 (Reapproved 1990) Standard Practice for Testing Homogeneity of Materials for the Development of Reference Materials

E 1019 - 93 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys

E 1724 - 95 Standard Guide for Testing and Certification of Metal and Metal-Related Reference Materials

E 1806 - 96 Standard Practice for Sampling Steel and Iron for Determination of Chemical Composition

E 1831 - 96 Standard Guide for Preparing Certificates for Reference Materials Relating to Chemical Composition of Metals, Ores, and Related Materials.

ISO Guides available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

ISO Guide 25 (Third edition, 1990), General requirements for the competence of calibration and testing laboratories.

ISO Guide 30 (Second edition, 1991), Terms and definitions used in connection with reference materials.

ISO Guide 31 (First edition, 1981), Contents of certificates of reference materials.

ISO Guide 33 (First edition, 1989), Uses of certified reference materials.

ISO Guide 34 (First edition, 1996), Quality system guidelines for the production of reference materials.

ISO Guide 35 (Second edition, 1989), Certification of reference materials - General and statistical principles.

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

Certificate Number 3972-022399p6