

Brammer Standard Company, Inc.

# Certificate of Analysis

BS 4972 (REVISION OF BS 56G)

Certified Reference Material<sup>1</sup> for AISI Carbon Steel Grade Number 1045  
(UNS Number G10450)

	Certified Value <sup>2</sup>	Estimate of Uncertainty <sup>3</sup>	Certified Value <sup>2</sup>	Estimate of Uncertainty <sup>3</sup>	
Analysis listed as percent by weight					
<b>C</b>	<b>0.460</b>	0.005	<b>Co</b>	<b>0.007</b>	0.0015
<b>Mn</b>	<b>0.74</b>	0.01	<b>N</b>	<b>0.0089</b>	0.0005
<b>P</b>	<b>0.015</b>	0.001	<b>Sn</b>	<b>0.028</b>	0.002
<b>S</b>	<b>0.024</b>	0.0015	<b>Ti</b>	<b>0.0015</b>	0.0005
<b>Si</b>	<b>0.335</b>	0.010	<b>V</b>	<b>0.012</b>	0.001
<b>Cu</b>	<b>0.220</b>	0.006			
<b>Ni</b>	<b>0.056</b>	0.003	<b>Information Values<sup>4</sup></b>		
<b>Cr</b>	<b>0.058</b>	0.003	<b>Mg</b>	0.0002	
<b>Mo</b>	<b>0.012</b>	0.002	<b>Nb</b>	<0.002	
<b>Al</b>	<b>0.002</b>	0.001	<b>O</b>	0.009	
<b>As</b>	<b>0.005</b>	0.001	<b>Pb</b>	0.001	
<b>B</b>	<b>0.0002</b>	0.0001	<b>Sb</b>	<0.004	
<b>Ca</b>	<b>0.0013</b>	0.0002	<b>W</b>	<0.01	

<sup>1</sup> Brammer Standard Company, Inc. is accredited by A2LA (Certificate Number 656.02) to ISO Guide 34 as a Reference Material Producer to produce Certified Reference Materials.

<sup>2</sup> The certified value listed is the present best estimate of the true value based on the results of an interlaboratory testing program..

<sup>3</sup> 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.

<sup>4</sup> Information values are not certified and are provided for information only.

<sup>5</sup> The uncertainty value for boron was editorially corrected from 0.0005 to 0.00005 on March 6, 2002.

See the following pages for more information.

Certificate Number 4972-020819p1

**Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895**  
**Telephone (281) 440-9396 Fax (281) 440-4432 brammerstandard.com**

Analysis	* C	* Mn	* P	* S	* Si	* Cu	* Ni	* Cr	* Mo
1	C 0.455	MnP 0.719	MPH 0.0132	C 0.022	AGA 0.324	AIC 0.209	AES 0.051	AA 0.0538	AIC 0.0104
2	C 0.4552	AIC 0.72	AIC 0.0135	C 0.0220	GSI 0.324	AA 0.209	MND 0.0531	XRF 0.0545	IN 0.0107
3	AGA 0.457	XRF 0.726	AIC 0.0136	C 0.0227	GSI 0.325	MCB 0.212	IN 0.0536	AIC 0.056	AIC 0.0108
4	C 0.459	AIC 0.73	MPN 0.0137	C 0.0228	AIC 0.330	XRF 0.215	AIC 0.0538	XRF 0.057	AIC 0.0109
5	C 0.4592	AA 0.733	AES 0.0149	C 0.0249	AIC 0.33	ECS 0.216	AIC 0.0540	AES 0.057	XRF 0.011
6	C 0.46	XRF 0.74	XRF 0.015	C 0.025	AIC 0.33	AES 0.217	AIC 0.055	AIC 0.0576	AIC 0.011
7	C 0.46	AIC 0.740	AIC 0.015	C 0.025	AIC 0.330	MCT 0.220	AIC 0.056	AIC 0.058	AIC 0.011
8	CP 0.4615	AIC 0.742	AES 0.015	AGA 0.0253	AES 0.332	AES 0.220	AIC 0.0564	AGA 0.058	AIC 0.0113
9	C 0.464	AGA 0.743	AIC 0.0155	CP 0.0254	MSI 0.332	AIC 0.222	AIC 0.057	AIC 0.058	AIC 0.0113
10	C 0.466	MnP 0.744	AGA 0.0159	C 0.0266	GSI 0.333	IN 0.222	AGA 0.058	AIC 0.0588	AGA 0.0115
11	C 0.466	MnP 0.746	AES 0.016		AIC 0.336	AIC 0.223	AES 0.058	AIC 0.059	XRF 0.0115
12		AA 0.749	AIC 0.016		XRF 0.34	AIC 0.223	GNI 0.059	AES 0.059	GMO 0.0116
13		AIC 0.749	AIC 0.0161		GSI 0.344	AIC 0.224	AIC 0.059	AIC 0.059	AIC 0.0118
14		AES 0.749	AIC 0.0162		AIC 0.346	AIC 0.224	AA 0.0594	MCS 0.0594	AA 0.012
15		AES 0.75	XRF 0.0165		XRF 0.353	AIC 0.226	AIC 0.0596	TCr 0.0599	AIC 0.012
16		AIC 0.75	AIC 0.0167		AIC 0.355	AGA 0.226	AIC 0.060	AIC 0.0599	MMo 0.0122
17		AES 0.75	AIC 0.017			AIC 0.228		IN 0.0601	AES 0.013
18		AIC 0.752	AIC 0.018					AIC 0.0613	AES 0.016
19		AIC 0.753							AES 0.0161
Average	0.4603	0.741	0.0154	0.0242	0.3353	0.2198	0.0564	0.0581	0.0119
Std Dev	0.0038	0.011	0.0013	0.0016	0.0097	0.0059	0.0028	0.0019	0.0016
Certified	0.460	0.74	0.015	0.024	0.335	0.220	0.056	0.058	0.012
t	2.2281	2.1009	2.1098	2.2622	2.1315	2.1199	2.1315	2.1098	2.1009
C(95%)	0.0026	0.005	0.0007	0.0012	0.0052	0.0030	0.0015	0.0010	0.0008
BS 56G	0.457	0.75	0.016	0.024	0.34	0.22	0.056	0.058	0.012

Analysis	* Al	* As	* B	* Ca	* Co	* N	* Sn	* Ti	* V
1	AES 0.001	MAD 0.0040	AES 0.00015	AES 0.00104	AIC 0.0058	FU 0.0083	AES 0.0267	AIC 0.001	AES 0.010
2	AES 0.001	AAH 0.0042	MBD 0.00017	AIC 0.0011	AIC 0.0058	FU 0.0085	AES 0.027	AIC 0.0011	AAA 0.0108
3	AIC 0.0013	AIC 0.0043	AIC 0.0002	AIC 0.00116	AIC 0.0060	FU 0.0085	AIC 0.0271	AIC 0.0011	AES 0.011
4	AAA 0.0015	AIM 0.0044	ASE 0.0002	AIC 0.0012	AIC 0.0061	FU 0.0086	AIC 0.0271	AES 0.0012	XRF 0.0115
5	AIC 0.0018	AES 0.0044	ASE 0.0002	AIC 0.0012	IN 0.0061	FU 0.0088	MSn 0.0272	AIC 0.0013	AES 0.0119
6	AIC 0.0018	AIC 0.0050	AES 0.0003	AAG 0.0012	AES 0.0062	FU 0.0088	AES 0.0274	AES 0.0015	AIC 0.012
7	AIC 0.0019	AES 0.005		AIM 0.0013	AAG 0.0062	FU 0.0088	AGA 0.0275	AIC 0.0016	AIC 0.0122
8	AIC 0.002	AES 0.005		AES 0.0013	AIC 0.0066	FU 0.0089	AIC 0.0276	AIC 0.0019	AIC 0.0122
9	AIC 0.0020	AAH 0.0054		AIC 0.0013	AIC 0.0066	FU 0.0089	AIC 0.028	AES 0.002	AIC 0.0122
10	AIC 0.002	AIH 0.0056		AIC 0.0013	AIC 0.0068	FU 0.00900	AIM 0.0282	AES 0.002	AIC 0.0123
11	AIC 0.002	AAH 0.0056		AES 0.0013	AIC 0.007	FUP 0.0091	AAG 0.0283		AIC 0.0124
12	AIC 0.0021	AAG 0.0056		AA 0.00137	AAA 0.0073	FU 0.0099	AA 0.029		IN 0.0125
13	AGA 0.0026	IN 0.0057		AAG 0.0014	AA 0.0084	FU 0.010	AIC 0.029		MVE 0.0128
14	AES 0.003	AES 0.006		AES 0.0016	XRF 0.009		AIC 0.0296		AIC 0.0129
15	AES 0.0040	AES 0.00615			AES 0.009		AIC 0.0299		AIC 0.0129
16	AIC 0.0043	AAG 0.0069			AES 0.009		AES 0.030		AIC 0.013
17							AIC 0.030		AES 0.013
18							AIC 0.031		AA 0.014
Average	0.0021	0.0052	0.00020	0.00127	0.0070	0.00893	0.0284	0.0015	0.0122
Std Dev	0.0009	0.0008	0.00005	0.00014	0.0012	0.00050	0.0013	0.0004	0.0009
Certified	0.002	0.005	0.0002	0.0013	0.007	0.0089	0.028	0.0015	0.012
t	2.1315	2.1315	2.5706	2.1604	2.1315	2.1788	2.1098	2.2622	2.1098
C(95%)	0.0005	0.0004	0.00005	0.00008	0.0006	0.0003	0.0006	0.0003	0.0005
BS 56G	0.002	(0.005)	(0.0004)	0.0012	0.009	0.0090	0.029	0.002	0.013

Analysis	* Mg	* Nb	* O	* Pb	* Sb	* W
1	AES 0.0001	AES <0.001	FU 0.0068	AES 0.0007	AES <0.001	AES <0.001
2	AES 0.00018	AES <0.002	FU 0.0085	AES 0.0012	AES <0.001	AES <0.005
3	AIC 0.0003	AIC 0.0003	FU 0.00890	AIC 0.0014	AA 0.0015	AES <0.01
4			FU 0.0097	AES 0.0014	AIC 0.0016	AES 0.003
5			FU 0.0098	AAG 0.0017	AES 0.003	
6			FU 0.0099			
7			FU 0.010			
Average	0.00019		0.0091	0.0013		
Std Dev	0.00010		0.0012	0.0004		
Information	(0.0002)	(<0.002)	(0.009)	(0.001)	(<0.004)	(<0.01)
BS 56G					(0.002)	<0.005

Data in parentheses are not certified but are provided for information only.

\* Methods of analysis listed on page 3

$C(95\%) = (t \times sd) / \sqrt{n}$  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

Code	Element	Method
AA		Flame Atomic Absorption Spectrometry
AAA		Flame Atomic Absorption - standard addition method
AAG		Electro-thermal atomization (graphite furnace) Atomic Absorption Spectrometry
AAH		Flame Atomic Absorption Spectrometry with hydride generation
AES		AES - Spark Source Optical Emission Spectrometry
AGA		AES - Spark Source and Glow Discharge Spectrometry average
AIC		AES - ICP -Inductively Coupled Plasma Spectrometry
AIH		AES - ICP -Inductively Coupled Plasma Spectrometry after hydride generation
AIM		AES - ICP Mass Spectrometry addition method
ASE		AES - Inductively Coupled Plasma after solvent extraction
C	C, S	Combustion-Infrared Absorption (ASTM E 1019) traceable to CRMs
CP	C, S	Combustion-Infrared Absorption traceable to pure substances
ECS	Cu	Sulphide precipitation, electro- deposition, gravimetric
FU	N, O	Inert gas Fusion Method (ASTM E 1019) traceable to CRMs
FUP	N	Inert gas Fusion Method traceable to pure substances
GMo	Mo	Gravimetry, Benzolnoxime
GNi	Ni	Dimethylglyoxime gravimetric
GSi	Si	Gravimetry with perchloric acid
IN		INAA - Neutron Activation Analysis
MAD	As	MAS - Molybdenum blue photometric after separation by distillation
MBD	B	MAS - Distillation separation-curcumin photometric
MCB Cu	MAS	MAS - Bicyclohexane oxalyldihydrazone photometric
MCS	Cr	MAS - Diphenyl carbazide photometric after separation with Na <sub>2</sub> CO <sub>3</sub>
MCT	Cu	MAS - Tetraethylthiuram disulphide
MMo	Mo	MAS - Thiocyanate after extraction with butyl acetate
MND	Ni	MAS - Dimethylglyoxime photometric
MnP	Mn	MAS - Potassium periodate oxidation photometric
MPH	P	MAS - Heteropoly molybdenum blue spectrophotometry
MPN	P	MAS - n-butyl alcohol-trichloromethane extraction photometric
MSi	Si	MAS - Molybdenum blue photometric method (ASTM E350)
MSn	Sn	MAS - Phenylfluorone photometric
MVE V	MAS	MAS - n-benzoyl phenylhydroxylamine extraction photometric
TCr	Cr	Perodisulphate oxidation titration
XRF		X-Ray Fluorescence spectrometry

AES = Atomic Emission Spectrometry

MAS = Molecular Absorption Spectrometry (photometric, spectrophotometric methods)

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

### Laboratory

AK Steel Research, Middletown, Ohio  
 ANAREM, Prague, Czech Republic  
 Brammer Standard Co., Inc., Houston, Texas  
 China National Analysis Center for Iron and Steel, Beijing, China  
 Crucible Specialty Steel, Syracuse, New York  
 J. Dirats and Co., Inc., Westfield, Massachusetts  
 IncoTest, Huntington, West Virginia  
 LECO Corporation, St. Joseph, Michigan  
 Shiva Analyticals (India) Ltd., Hoskote, Bangalore, India  
 VHG Laboratories, Inc., Manchester, New Hampshire

### Laboratory contact

Howard P. Vail  
 Karel Bičovský  
 Richard P. Beaumont  
 Prof. Wang Haizhou  
 William Mastroe  
 Eric E. Dirats  
 Melissa G. Staley  
 Dennis Lawrenz  
 Dr. T. V. Ramakrishna  
 Julie M. McIntosh

**Certificate Number 4972-020819p3**

**Additional analytical data:** This material was used as an unknown test specimen number 4972 in a nationally recognized

Proficiency Testing Program (PTP) for low-alloy steel. Most of the participating laboratories used one or more of the ASTM Standard Test Methods E 322, E 415, E 1019, and E 1085. The PTP data was not used in calculating the certified values listed on pages 1 and 2. The data shown below are the results from the PTP.

#### Combustion Instrument Analysis using ASTM Standard Test Method E 1019

	C	S	N	O
Number of Labs	63	59	50	33
Grand Average	0.4612	0.0248	0.0088	0.0097
Standard Deviation	0.0078	0.0018	0.0003	0.0010

#### Optical Emission Spectrometric Analysis using ASTM Standard Test Method E 415

	C	Mn	P	S	Si	Cu	Ni	N
Number of Labs	73	86	86	81	86	80	80	11
Grand Average	0.4623	0.7401	0.0160	0.0260	0.3315	0.2175	0.0569	0.0089
Standard Deviation	0.0094	0.0134	0.0013	0.0021	0.0122	0.0074	0.0028	0.0006

	Cr	Mo	Al	Sn	Ti	V
Number of Labs	81	77	77	64	69	82
Grand Average	0.0574	0.0116	0.0034	0.0281	0.0021	0.0122
Standard Deviation	0.0030	0.0020	0.0014	0.0020	0.0008	0.0012

#### X-ray Emission Spectrometric Analysis using ASTM Standard Test Method E 322

	Mn	Cu	Ni	Cr
Number of Labs	10	11	10	10
Grand Average	0.7474	0.2201	0.0562	0.0565
Standard Deviation	0.0093	0.0053	0.0020	0.0029

#### X-ray Emission Spectrometric Analysis using ASTM Standard Test Method E 1085

	Mn	P	S	Si	Cu	Ni	Cr	Mo	V
Number of Labs	9	8	5	9	8	7	6	8	7
Grand Average	0.7438	0.0153	0.0246	0.3376	0.2207	0.0562	0.0570	0.0126	0.0128
Standard Deviation	0.0118	0.0014	0.0044	0.0240	0.0050	0.0030	0.0027	0.0019	0.0015

**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 Certified 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 discs in accordance with ASTM Standard Practice E 1806. The laboratories participating in the testing normally followed the requirements of ISO Guide 25 and/or ISO Standard 17025. 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 Method E 1019 and E 415 plus additional ICP and AA spectrometric methods.

**Outliers:** Some outlying data was excluded from the data listed on page 2 due to technical assessment of the cooperating laboratories and statistical evaluation.

**Traceability:** The following Certified Reference Materials were used to validate the analytical data listed on page 2: SRM 13g, 32b, 36a, 73c, 106b, 166b, 343a, 361, 362, 2166; ECRM 088-1; CKD 180A through 189A; JSS 168 - 171.

**Certificate Number 4972-020819p4**

**Homogeneity:** This Reference Material was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by optical emission spectrometry using ASTM Standard Test Method E 415 and found to be compatible with the

following Reference Materials: SRM C1173, 1261a, 1262a, 1263a, 1264a, 1265a, 1761, 1762, 1763, 1764, 1765, 1766, 1767; ECRM 186-1, 191-1; SS 457/1, 458/1; JSS 169-1, 170-6, 171-4.

**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. Whereas this material is in a solid form and stable, no expiration date is specified.

**Source:** This material was produced by Nucor Cold Finish, Brigham City, Utah. It was melted by an electric arc furnace, bottom poured into ingots, hot rolled into billets, rolled in to bars, ground and polished .

**Form:** This Reference Material is in the form of a disc, approximately 38 mm in diameter and 19 mm thick.

**Use:** This Reference Material is intended for use in optical emission and x-ray spectrometric methods of analysis. Refer to ISO Guide 33 for information about the use of Reference Materials.

**Certified area:** The entire depth of the disc may be used.

**Caution:** As with any bar material, avoid optical emission spectrometric burns in the center of the disc (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 you use for production specimens. Avoid overheating the disc during surface preparation.

**Certificate Number:** The unique identification number for this certificate of analysis is 4972-050301-px, where x indicates the page number. Refer to future Brammer Standard Company catalogs for information on any revisions to this or other Brammer Standard reference materials. You may also obtain information on revisions of certificates from the internet at [brammerstandard.com](http://brammerstandard.com).

**Revision information:** A new interlaboratory testing program (ITP) was initiated for this material when a replacement was tested. There were no dramatic changes in the analyses originally certified . Arsenic and boron were added to the list of certified values. The original values certified on February 2, 1992, are listed on page 2 at the bottom of each table. The original part number was BS 56G with certificate number 56G-020292. On February 8, 2019 the uncertainty value for B was corrected.

**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.	Phone: (281) 440-9396	web	<a href="http://www.brammerstandard.com">www.brammerstandard.com</a>
14603 Benfer Road			
Houston, Texas 77069-2895 USA	Fax: (281) 440-4432	e-mail	<a href="mailto:contact@brammerstandard.com">contact@brammerstandard.com</a>

Certified by: \_\_\_\_\_ on February 8, 2019.

Beau R. Brammer  
President

**Certificate Number 4972-020819p5**

**Brammer Standard Company, Inc., is accredited to ISO Guide 34 as a Reference Material Producer for the production of Certified Reference Materials and Reference Materials by A2LA (Certificate Number 656.02) The scope of accreditation is listed on the website: [www.brammerstandard.com](http://www.brammerstandard.com)**

**By Certificate Number 10539, the Quality System of Brammer Standard Company, Inc., is registered to ISO 9002:1994 by National Quality Assurance, U.S.A.**

**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 322 - 96 Standard Test Method for X-Ray Emission Spectrometric Analysis of Low-Alloy Steels and Cast Irons

E 415 - 85 (Reapproved 1999) Standard Test Method for Optical Emission Vacuum Spectrometric Analysis of Carbon and Low-Alloy Steel

E 826 - 85 (Reapproved 1996) Standard Practice for Testing Homogeneity of Materials for the Development of Reference Materials

E 1019 - 2000 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys

E 1085 - 95 Standard Test Method for X-Ray Emission Spectrometric Analysis of Low-Alloy Steels

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 Global Engineering - www.global.ihs.com*

ISO Standard 17025 (First edition, 1999), General requirements for the competence of calibration and testing laboratories.

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 (Second edition, 2000), Reference materials -Contents of certificates and labels.

ISO Guide 33 (Second edition, 2000), Uses of certified reference materials.

ISO Guide 34 (Second edition, 2000), General requirements for the competence of reference material producers.

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 4972-020819p6**